Advanced Computer Networks

Content-Centric Networking (III)

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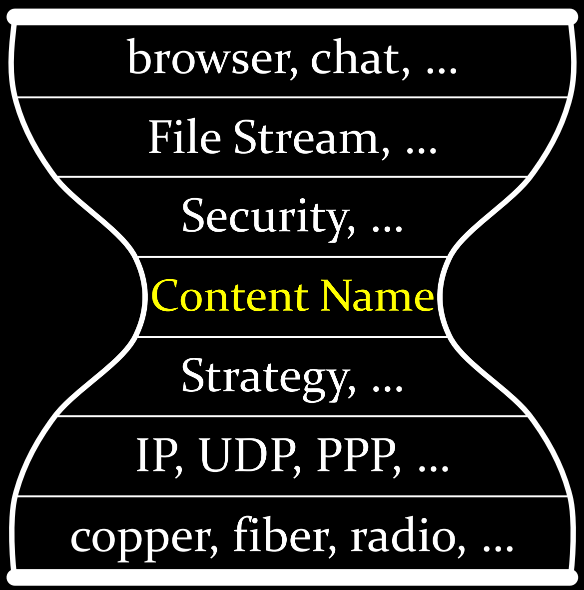
Review

- **Why COPSS?**
  - Temporal separation between providers (publishers) and consumers (subscribers)
  - NDN cannot achieve this via pure query/response model
  - The add-on systems to mitigate the mismatch also introduces overhead

REVIEW

- Why COPSS?
- **How does COPSS achieve Content-Centric Pub/Sub? (protocol level)**



Content Name:

/ugoe.edu/jchen/acn14-ICN.pdf/_v1/_s1

Content Descriptors:

/networking/ICN
/ugoe.edu/acn/2014
/ugoe.edu/jchen

Review

- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- **What are the 2 new packet types in COPSS?**

Content Name
Selector (order preference, publisher filter, scope, ..)
Nonce

Interest (Request)

Content Descriptor
Selector (order preference, publisher filter, scope, ..)
Nonce

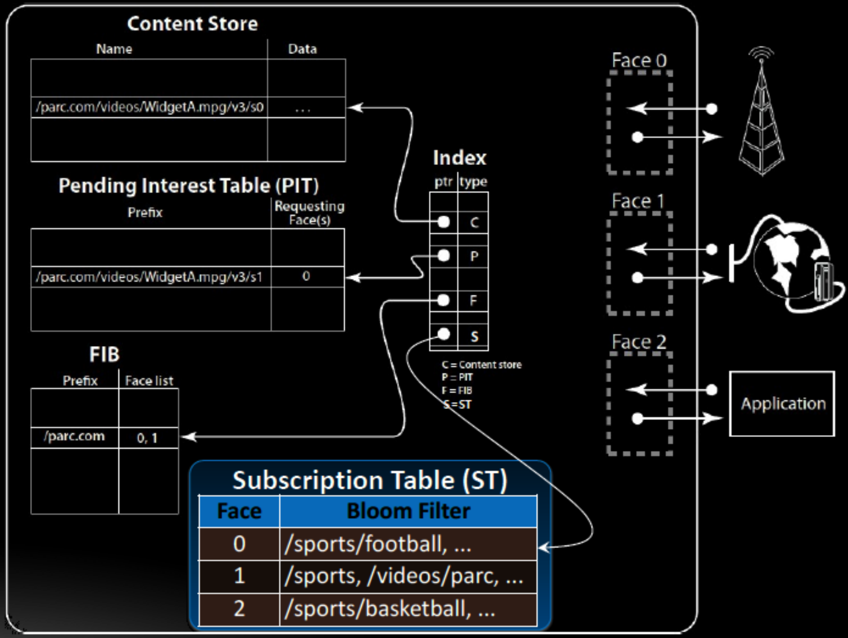
Subscription

Content Name
Content Descriptors
Signature (digest algorithm, witness, ...)
Signed Info (publisher ID, key locator, stale time, ...)
Data

Data (Response)
or
Publish

REVIEW

- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- What are the 2 new packet types in COPSS?
- **What are the data structures in a COPSS forwarding engine? And functions?**
    - Forwarding Information Base (FIB)
    - Pending Interest Table (PIT)
    - Subscription Table (ST)
    - Content Store



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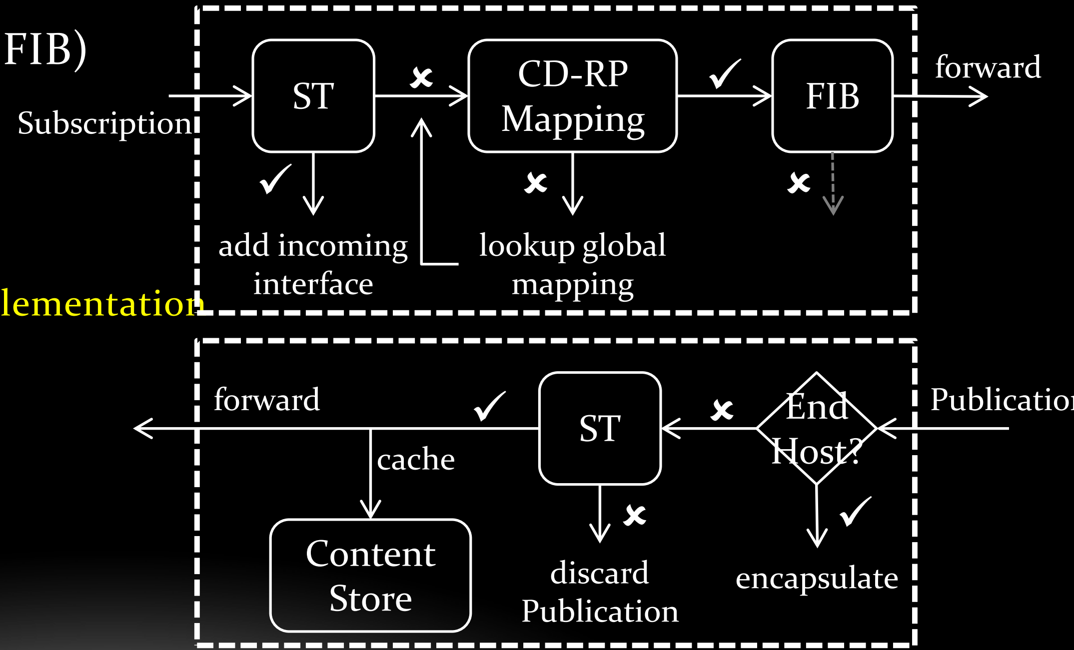
  - * You can separate RP module in implementation



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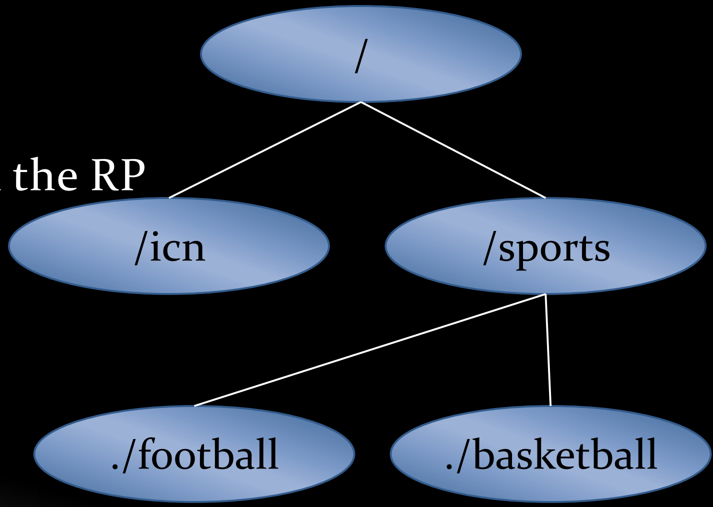
- What are the 2 new packet types in COPSS?
- What are the data structures in a COPSS forwarding engine? And functions?
- **What is Rendezvous-Point (RP) based communication? How to avoid information concentration?**
  - An RP serves … ch)
  - All the public … gh the RP
  - Automatic RP …
  - Note: RP is ju…

Prefix	RP Name
/	/RP1
/icn	/RP2
/sports	/RP3
/sports/football	/RP4
/sports/basketball	/RP5



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- **How to control CD-RP Map size and ST size for scalability?**
  - CD-RP lookup like DNS
  - Bloom-Filter ST

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- What is Rendezvous-Point (RP) based communication? How to avoid information concentration?
- How to control CD-RP Map size and ST size for scalability?
- **Why gaming is related to COPSS?**
  - Online gaming needs a communication infrastructure
  - Gaming is content-centric
  - Gaming is pub/sub

Review

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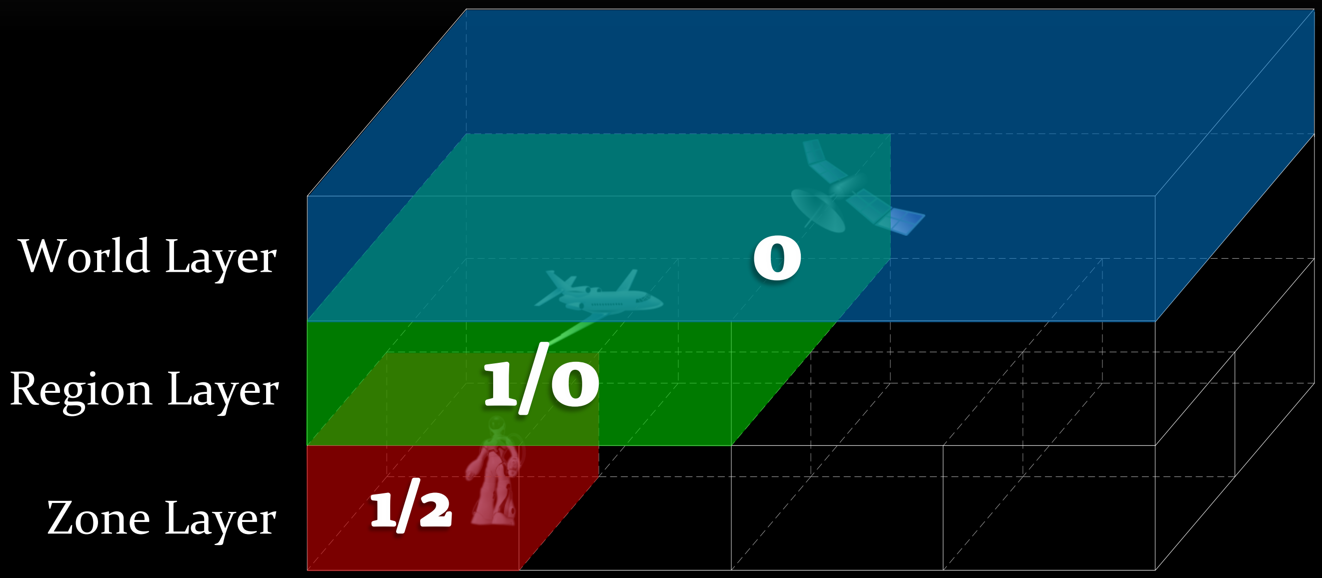

Satellite:
- Location: 0
- Pub: /0
- **Sub: /**

Plane:
- Location: 1/0
- Pub: /1/0
- **Sub: /1, /0**

Soldier:
- Location: 1/2
- Pub: /1/2
- **Sub: /1/2, /1/0, /0**

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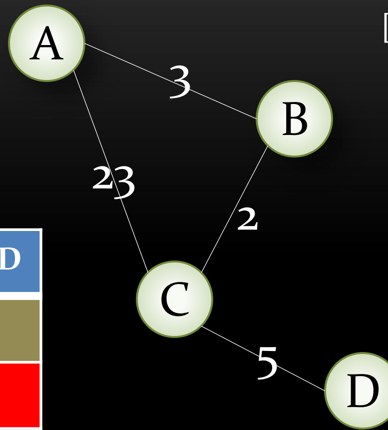
- What is Rendezvous-Point (RP) based communication? How to avoid information concentration?
- How to control CD-RP Map size and ST size for scalability?
- Why gaming is related to COPSS?
- Hierarchical map partitioning → Hierarchical CD structure?
- **Two-step communication?**
    - Subscriber interest
    - Policy control

HMMM… ICN ROUTING, OLD TALE, NEW DESIGN

- Routing
  - Network as a distributed system
  - Send a packet to a desired destination
- Old tale – IP routing
  - Distance Vector Routing – RIP [1]
  - Link State Routing – OSPF [2]
  - Inter-Domain Routing – BGP [3]

Distance Vector Routing – RIP

- Routing Information Protocol (RIP)
  - Bellman-Ford Algorithm
  - T=0



[4]

From A	Via A	Via B	Via C	Via D
To A				
To B		3		
To C			23	
To D				

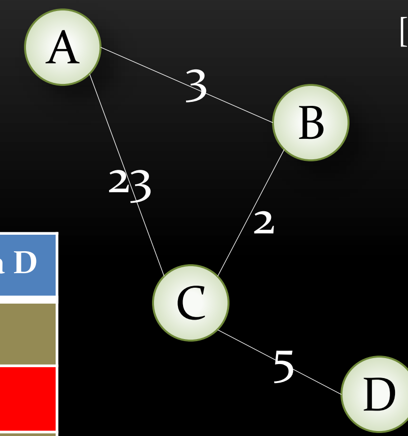
From B	Via A	Via B	Via C	Via D
To A	3			
To B				
To C			2	
To D				

From C	Via A	Via B	Via C	Via D
To A	23			
To B		2		
To C				
To D				5

From D	Via A	Via B	Via C	Via D
To A				
To B				
To C			5	
To D				

DISTANCE VECTOR ROUTING – RIP

- Routing Information Protocol (RIP)
  - Bellman-Ford Algorithm
  - T=1



[4]

From A	Via A	Via B	Via C	Via D
To A				
To B		3	25	
To C		5	23	
To D			28	

From B	Via A	Via B	Via C	Via D
To A	3		25	
To B				
To C	26		2	
To D			7	

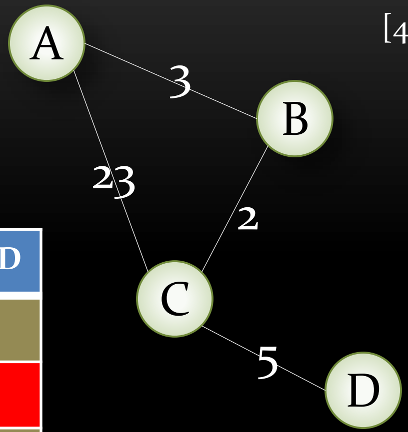
From C	Via A	Via B	Via C	Via D
To A	23	5		
To B	26	2		
To C				
To D				5

From D	Via A	Via B	Via C	Via D
To A			28	
To B			7	
To C			5	
To D				

Distance Vector Routing – RIP

- Routing Information Protocol (RIP)
  - Bellman-Ford Algorithm
  - T=2

[4]



From A	Via A	Via B	Via C	Via D
To A				
To B		3	25	
To C		5	23	
To D		10	28	

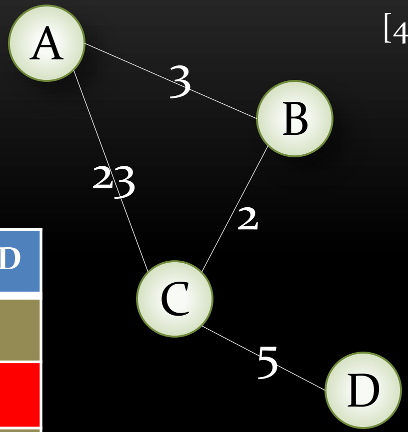
From B	Via A	Via B	Via C	Via D
To A	3		7	
To B				
To C	8		2	
To D	31		7	

From C	Via A	Via B	Via C	Via D
To A	23	5		33
To B	26	2		12
To C				
To D	51	9		5

From D	Via A	Via B	Via C	Via D
To A			10	
To B			7	
To C			5	
To D				

Distance Vector Routing – RIP

- Routing Information Protocol (RIP)
  - Bellman-Ford Algorithm
  - T=3



[4]

From A	Via A	Via B	Via C	Via D
To A				
To B		3	25	
To C		5	23	
To D		10	28	

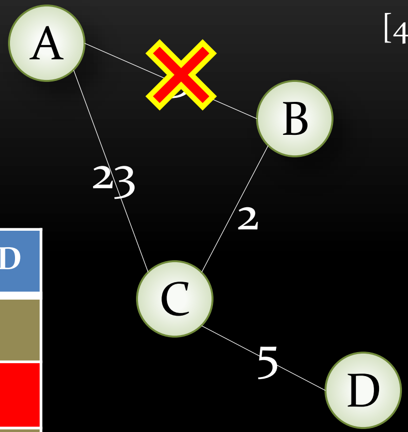
From B	Via A	Via B	Via C	Via D
To A	3		7	
To B				
To C	8		2	
To D	13		7	

From C	Via A	Via B	Via C	Via D
To A	23	5		15
To B	26	2		12
To C				
To D	33	9		5

From D	Via A	Via B	Via C	Via D
To A			10	
To B			7	
To C			5	
To D				

Distance Vector Routing – RIP

- Routing Information Protocol (RIP)
  - Bellman-Ford Algorithm
  - Issue: count to infinity



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To A				
To B		3	25	
To C		5	23	
To D		10	28	

From B	Via A	Via B	Via C	Via D
To A	3		7	
To B				
To C	8		2	
To D	13		7	

From C	Via A	Via B	Via C	Via D
To A	23	5		15
To B	26	2		12
To C				
To D	33	9		5

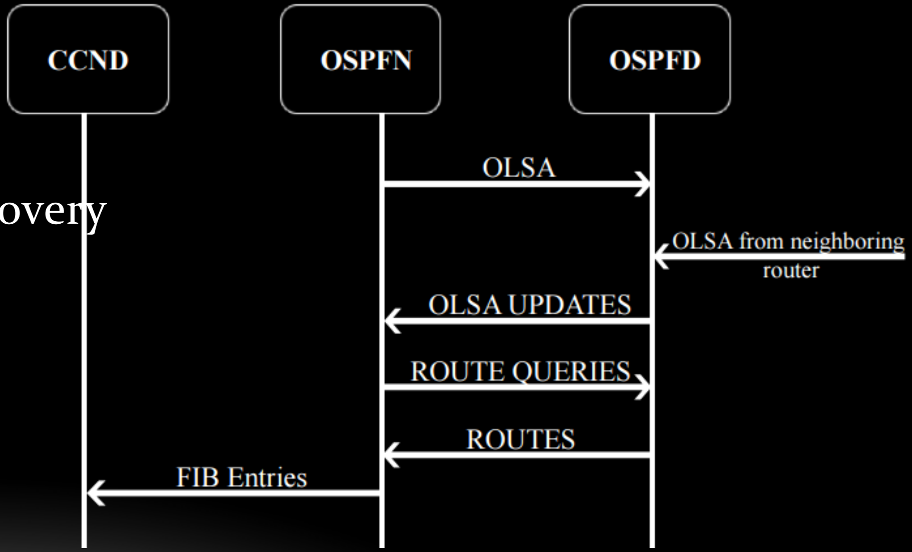
From D	Via A	Via B	Via C	Via D
To A			10	
To B			7	
To C			5	
To D				

Link State Routing – OSPF

- Open Shortest Path First (OSPF)
  - Routers exchange information about the links “in the world”
  - Dijkstra algorithm on each router
  - Issues:
    - Storage complexity
    - Computation complexity

ICN: Link State Routing – New Design

- OSPF-N [5]
  - OSPF+Name
  - Data Structures:
    - Name prefix table: name prefix → advertising Router
    - OSPF Routing Table: Destination → Next Hop
      - Managed by OSPF
  - Optimization: NLSR [6]
    - Multipath Calculation, Failure Recovery
  - Scalability Issue:
    - Size of name prefix table?



Solve Scalability Issue: Aggregation

- A solution suggested by NDN tech report (ISP-based aggregation) [7]:
  - Components:
    - Hierarchical provider assigned names (aggregation)
    - A mapping service: user-selected names → provider assigned names
  - E.g.,
    - AT&T assigns names in format: /att/%location%/%user%
    - User Alice chooses name: /aliceblog
    - Mapping service: /aliceblog → /att/atlanta/alice/aliceblog
  - Issue: misplaced data
    - Scalability issue still exists, but shifted from routing to mapping

Solve Scalability Issue: Distributed Resolution

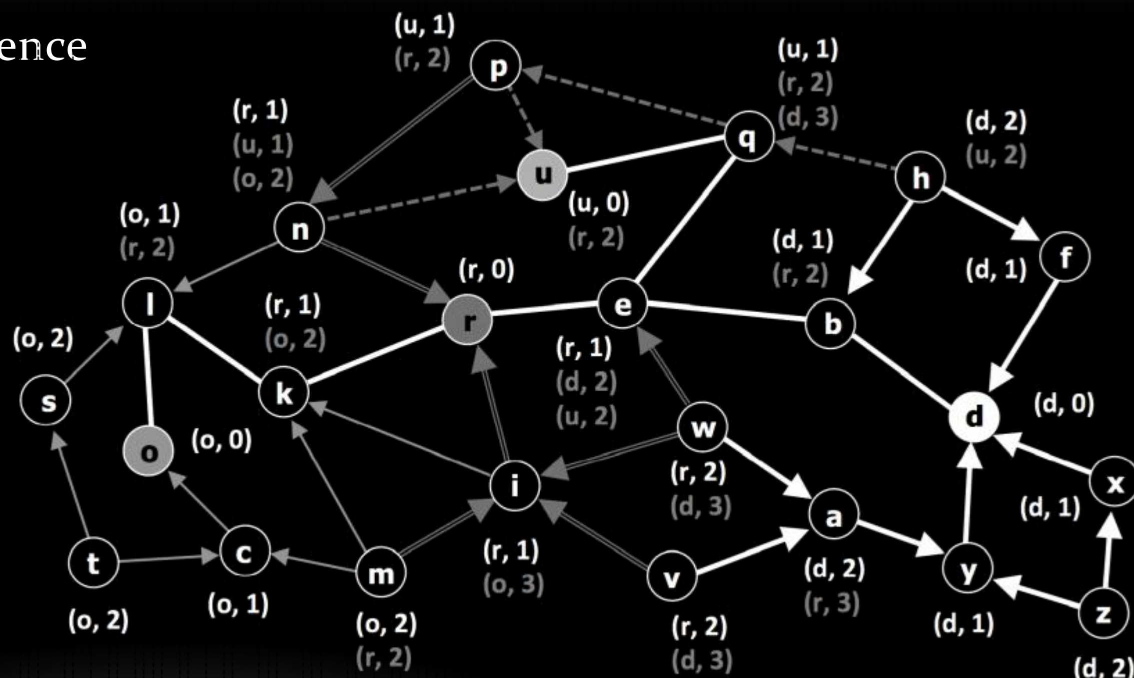
- MobilityFirst Project [8,9]:
  - GNRS (Global Name Resolution Service) [10]
    - DNS-like solution
    - DHT-like solution
    - Compare to traditional DNS:
      - Lower update latency (for mobility)
      - Multi-path, Multi-source support

Solve Scalability Issue: Reactive

- Reactive Routing [11, 12, 13]
  - Basic method:
    - Use FIB as cache (similar to DNS)
    - On FIB miss, broadcast Interest
    - When data passes back, write FIB table
  - Efficiency Issue:
    - Broadcast every unknown Interest!
    - Multiple data coming back and discarded on the way
  - Question:
    - Why can't the routers request for new FIB (similar to DNS) on miss?

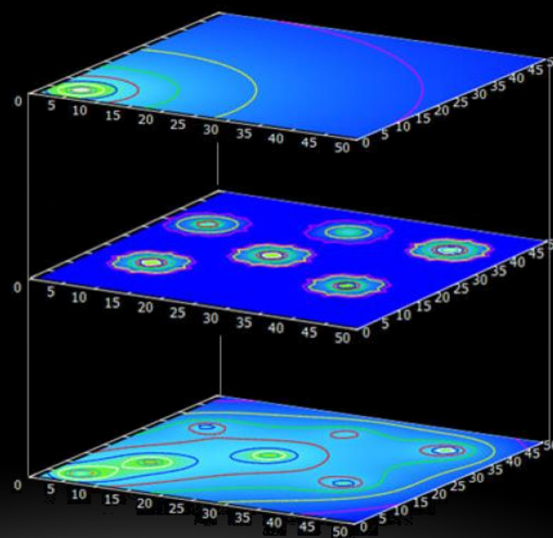
Solve Scalability Issue: Distance Vector

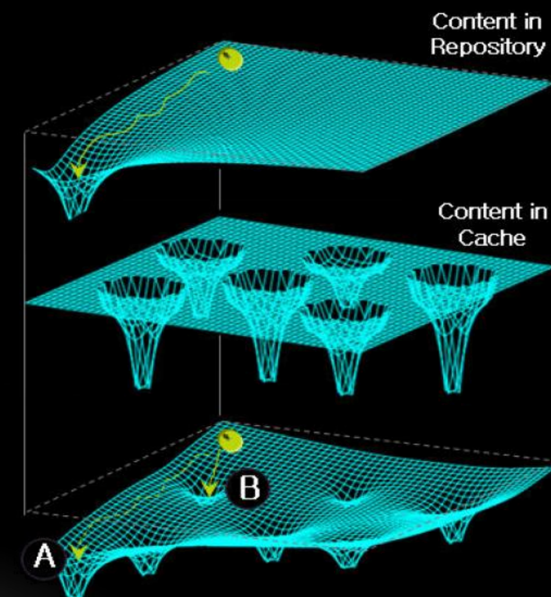
- Distance-based Content Routing (DCR) [14]:
  - Method:
    - Each router stores distance to nearest anchor
    - Anchors exchange existence
  - Issues:
    - Control overhead
    - Scalability



Solve Scalability Issue: Potential Based

- Cache Aware Target idenTification (CATT) [15]
  - Potential Field
    - Permanent potential field (PPF)
    - Volatile potential field (VPF)
    - Combined potential field (CPF)

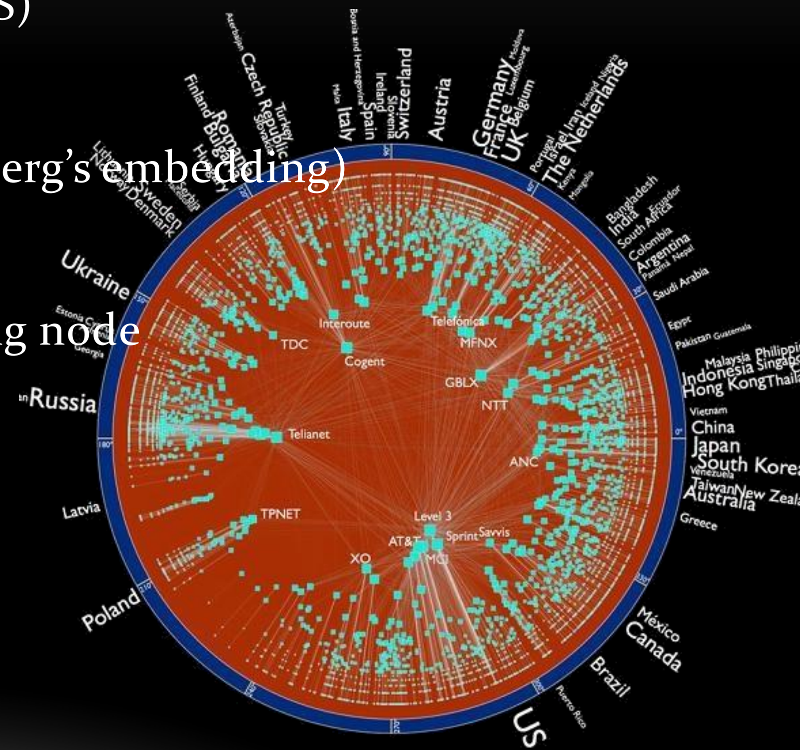




- Other cache-aware routings…

Solve Scalability Issue: Cooperative

- Hash-based cooperative [16,17]:
  - Idea (similar to P2P):
    - Data → Hash value (MD5, SHA1, Prefix-S)
      - Node balancing
    - Node → Hash value (MD5, SHA1, Kleinberg's embedding)
      - Topology awareness
    - Store data (or an entry) on corresponding node
  - Issues
    - Longest prefix match?
    - Aggregation?

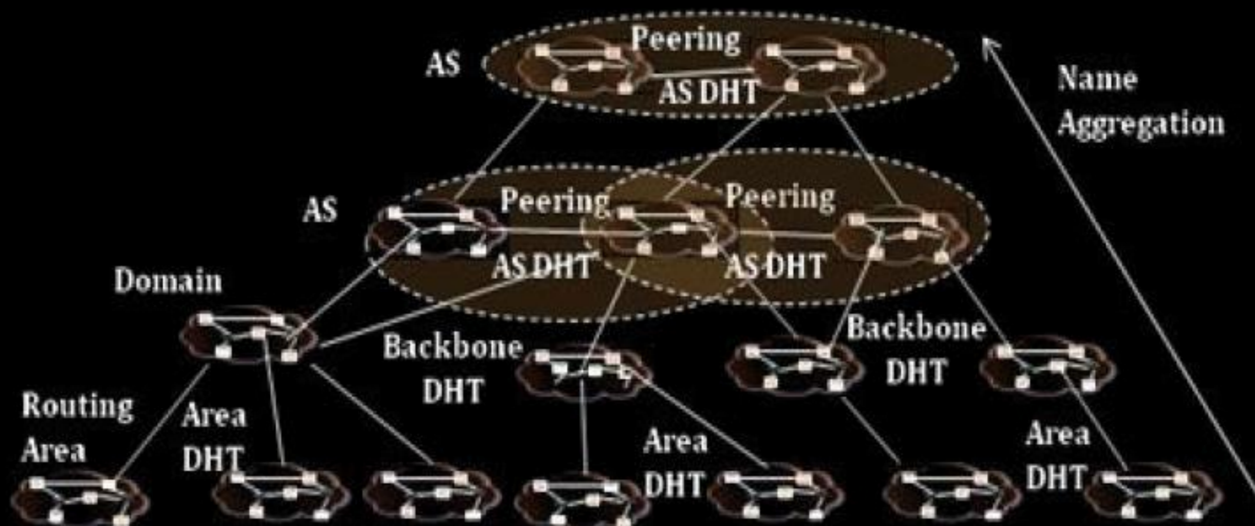


Inter-Domain Routing – BGP

- Border Gateway Protocol (BGP)
  - To address:
    - Large # of Autonomous Systems (AS)
    - Complicated policy among Ases
      - Provider – customer
      - Peering
  - Concept:
    - On border gateway, maintain a table:
      - Address space → next hop, preferrence

INTER-DOMAIN ROUTING IN ICN

- Scalable Multi-level Virtual Distributed Hash Table (SMVDHT) [18]:



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