INTERCONNECTING CDNS
AKA "PEERING PEER-TO-PEER"

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Outline

- Background: "peering peer-to-peer providers"
- CDN Interconnect Motivation
- CDNI Technical Issues
- Discussion

Why is this a P2PRG item?

- My interest in CDN Interconnect started with "peering peer-to-peer providers"
  - Balakrishnan, Shenker and Walfish paper from IPTPS 2005 proposed a model for interconnecting SP-operated DHTs
  - If you happen to build a CDN using a DHT infrastructure, then CDN interconnect looks a lot like DHT peering
  - Even without DHTs, lots can be leveraged from inter-DHT interface
- Likely need for standardization, but needs pre-standards work now

Peering DHTs
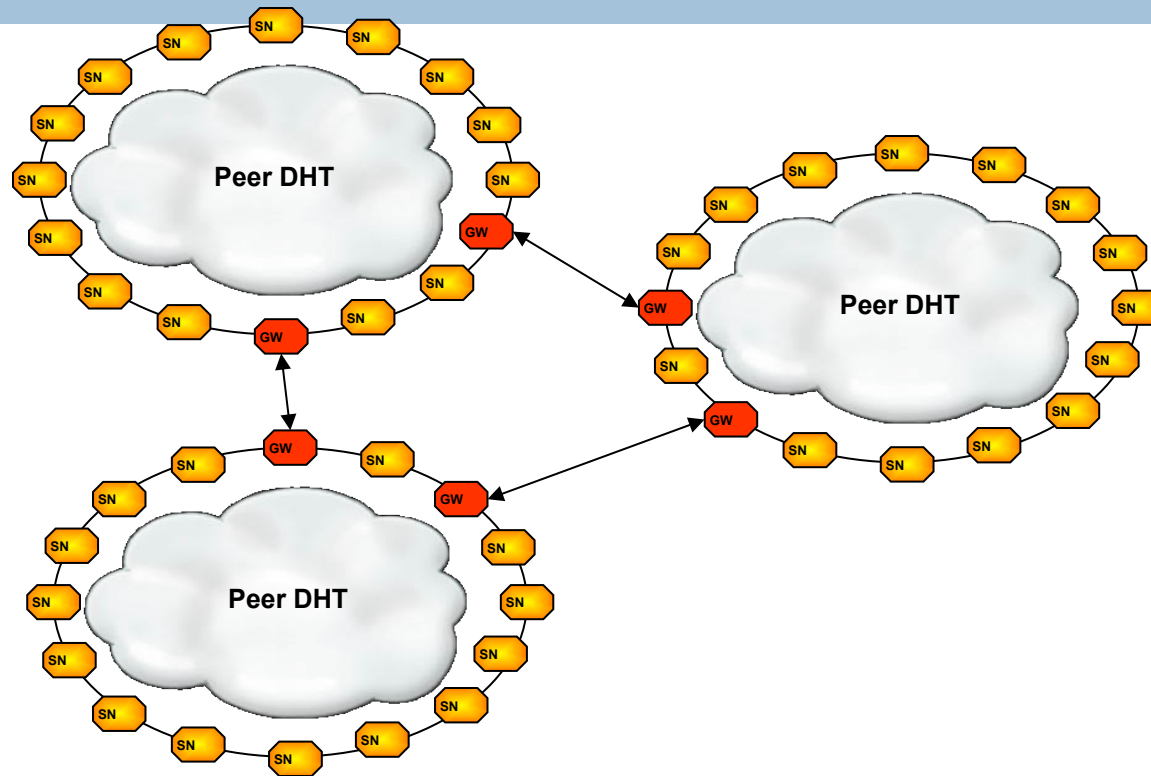
- Each AS/provider operates one DHT serving full keyspace
- Select nodes (peering gateways) can communicate across rings
- While each ring serves the entire DHT keyspace, not all content is in each ring

DHT interface

- A DHT provides a "put, get" interface
  - `Put(key, value)` stores `value` at location `key`
  - `Get(key)` returns `value` from location `key`
- This is roughly what OpenDHT provided as its API
- Also a reasonable inter-DHT interface
  - No requirement that internal implementation is a DHT
- You can build content delivery on top of this
  - use `key` to name the content (e.g. hash of a URI/URL) and `value` to store the content or a pointer to it

DHT Interconnect options

1. Broadcast Put
   - When (k,v) is put into one DHT, the same (k,v) is put to all other DHTs
   - Results in all descriptors being stored in all rings

2. Broadcast Get
   - (k,v) is put in one DHT only
   - get(k) is broadcast to all DHTs
   - content stored in original DHT, may be cached in others

3. Broadcast Put of Key Only
   - (k,v) is put in one DHT only
   - (k, DHT) is broadcast to all DHTs
   - get(k) can be forwarded directly to origin DHT

Towards Open Content Delivery

- Content Delivery is currently siloed into parallel,
  non-interoperable CDN "islands"
- A more open global Content Delivery architecture and infrastructure is desired:
  - To maximize QoE
  - To support wide range of business models (including a redistribution of revenue across involved parties that aligns better with respective costs)
- CDN Interconnect is an enabling technology for such an Open Content Delivery infrastructure

CDN Interconnect Vision

- CDN providers should be able to interconnect freely, as ISPs do today
    - Should support a wide range of "money flow" models
- Arguably, today's big global CDNs are analogous to the walled-garden packet networks that preceded the Internet
- Hope to reap the same benefits that the Internet's interconnection model brought to packet networks

Related Standardization Efforts

- IETF
  - Prior "CDN Internetworking" effort in IETF
  - CDNI WG produced some info RFCs:
    - RFC 3466 A Model for Content Internetworking (CDI)
    - RFC 3570 Content Internetworking (CDI) Scenarios
  - CDNI WG put on hold in 2003 (actual protocols not specified)
- Open IPTV Forum (OIPF)
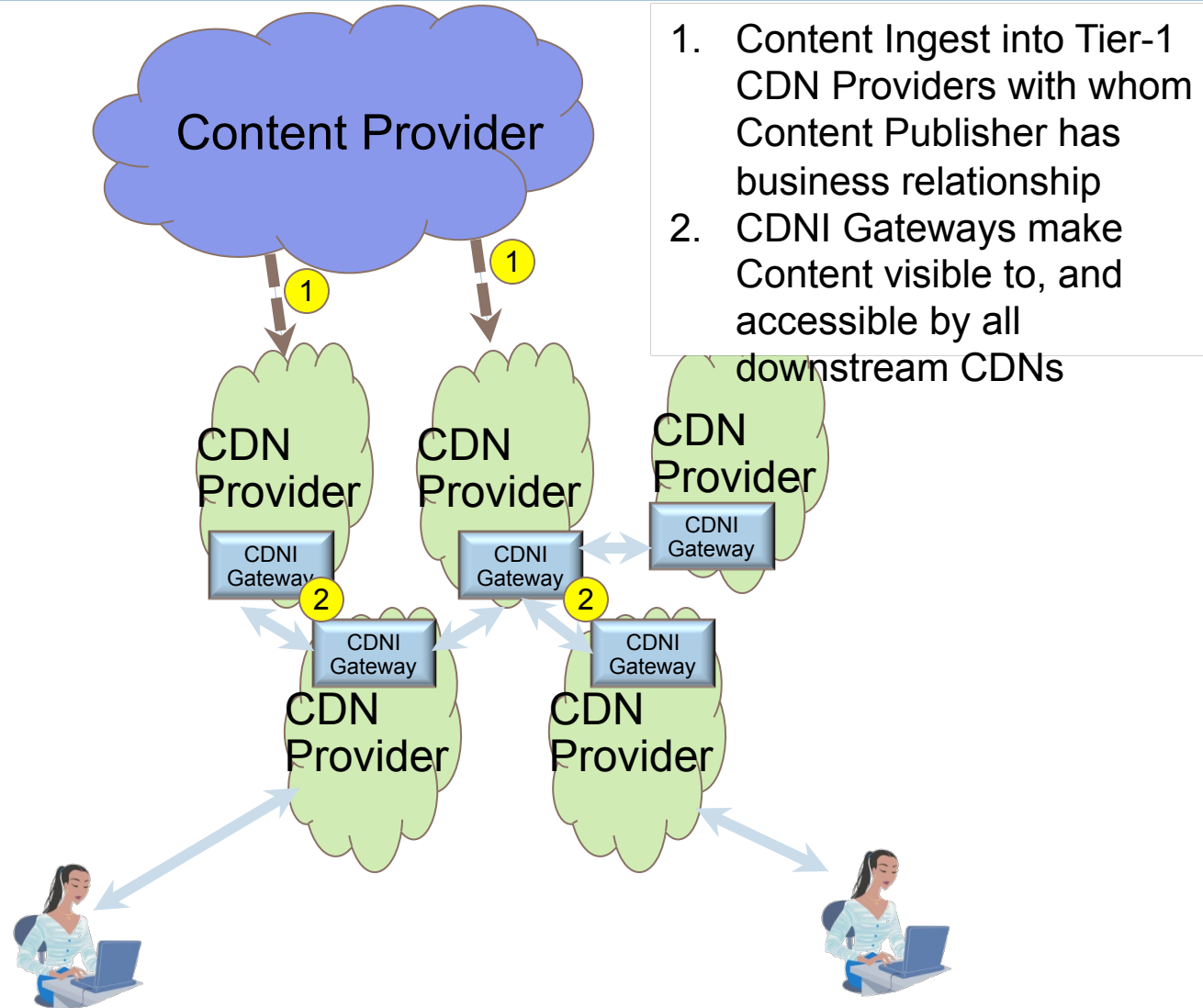 - CDN in scope, but left for Rel2, will probably not cover CDN Interco initially
- ETSI TISPAN
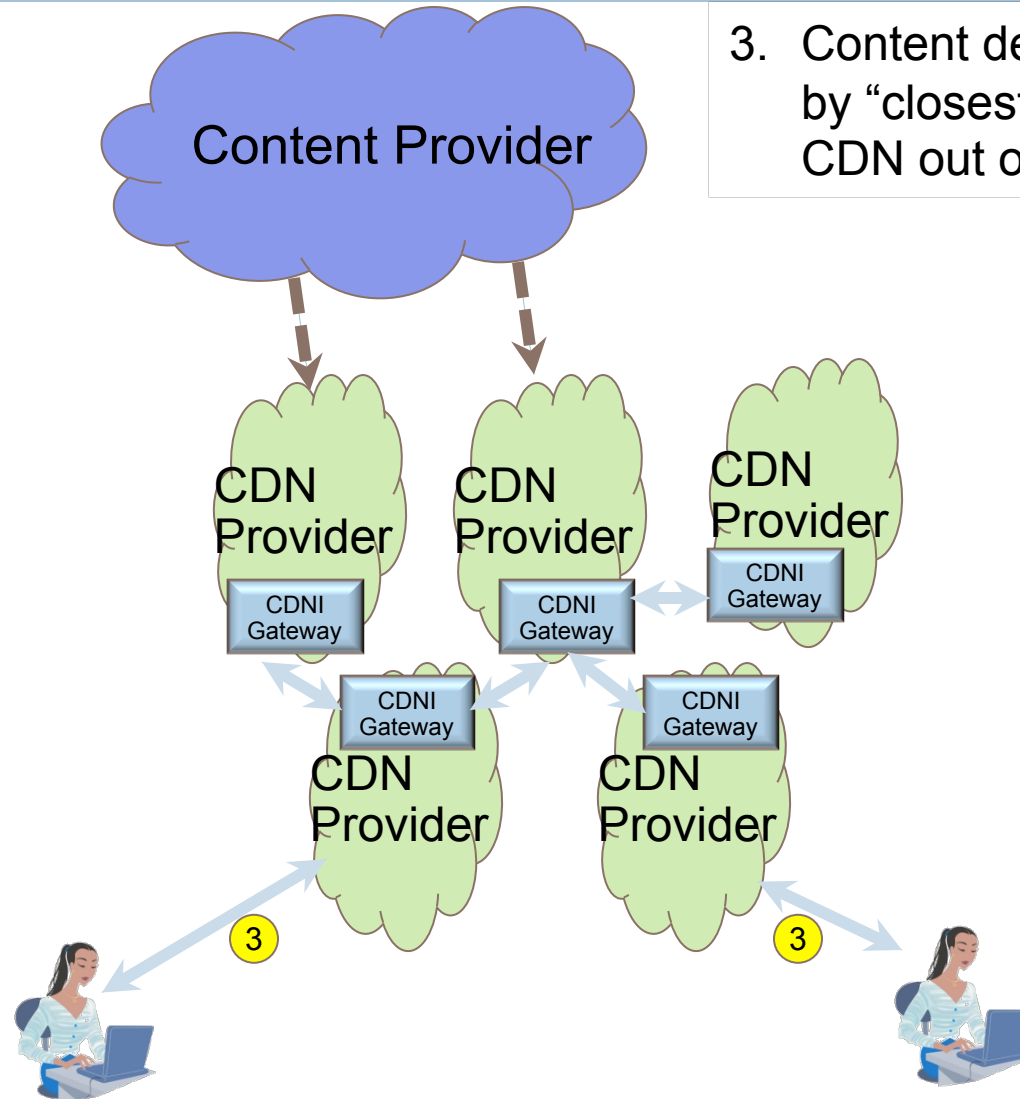 - Some work on CDN in scope for Rel 3, does not seem to cover CDNI

Towards Open Content Delivery

- CDN Infrastructure & Services being deployed by ISPs, telcos, Cable operators, Mobile operators,…
- Opportunity to Interconnect these CDNs to offer a compelling Open Content Delivery service
- Will allow Content Publishers to reach more users, with higher QoE, with fewer contractual relationships
- Will allow CDN operators to:
  - Monetize their infrastructure to deliver more content (e.g. from Content Publishers with whom they don't have a direct relationship)
  - Participate in a "Global" CDN
  - Act as "CDN aggregator" for Content Publishers

CDN Interconnect

1. Content Ingest into Tier-1 CDN Providers with whom Content Publisher has business relationship
2. CDNI Gateways make Content visible to, and accessible by all downstream CDNs

Content Provider

CDN Provider

CDN Provider

CDN Provider

CDNI Gateway

CDNI Gateway

CDNI Gateway

CDNI Gateway

CDNI Gateway

CDN Provider

CDN Provider

CDN Interconnect

Content Provider

3. Content delivered to user by "closest" downstream CDN out of many

CDN Provider

CDN Provider

CDN Provider

CDNI Gateway

CDNI Gateway

CDNI Gateway

CDNI Gateway

CDNI Gateway

CDN Provider

CDN Provider

3

3
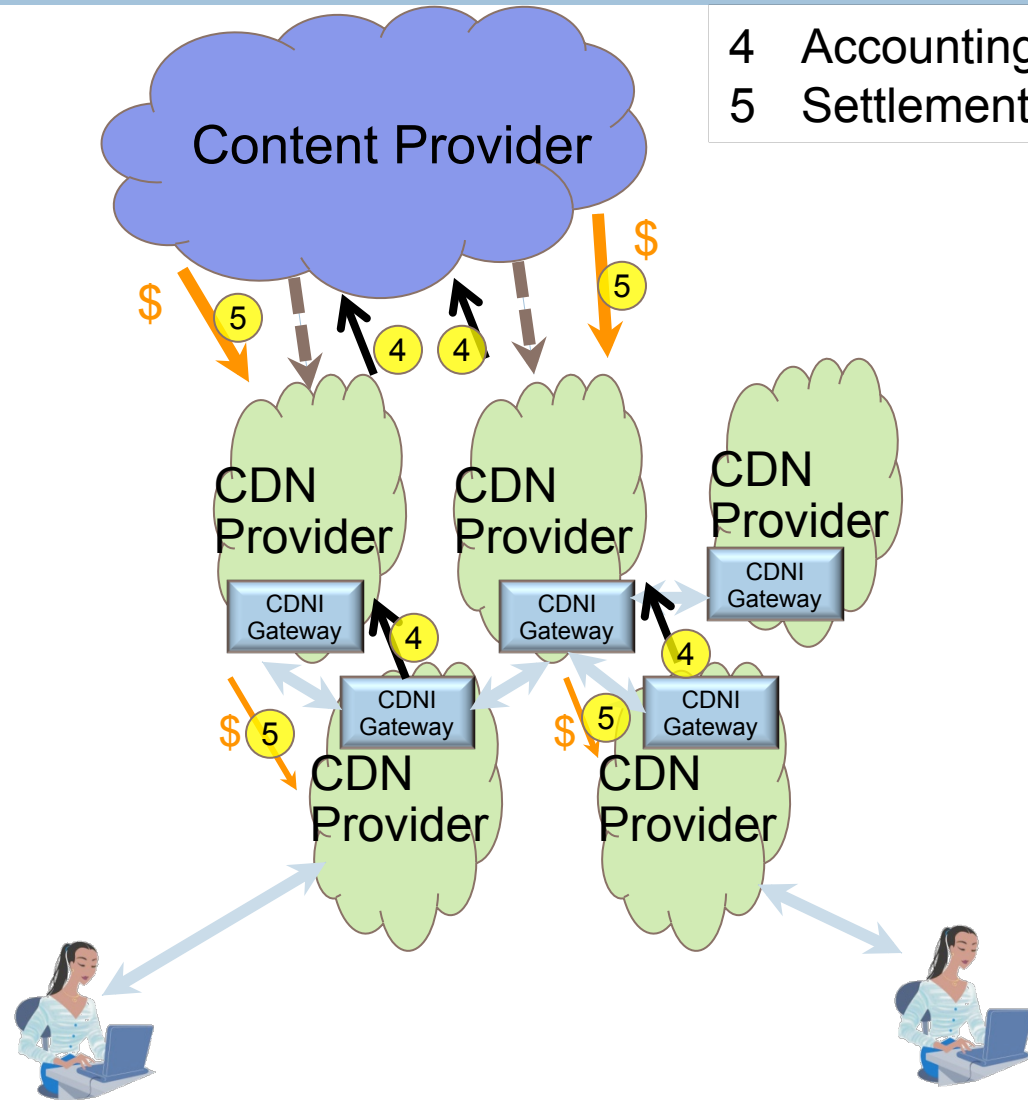
CDN Interconnect

CDN Interconnect Functional Components

- Request-Routing
  - How to steer user request towards right Surrogate in right CDN
- Content Distribution
  - How serving Surrogate acquires the asset through CDN Mesh
- Accounting
  - How volume of requests served by each CDN are recorded and used for settlement
- Reporting
  - How Content Publisher & CDN Providers can track serving activity (in their CDN and downstream) :
    - Near-Real time
    - Detailed Log

Request Routing

- There are a handful of ways to cause a client to fetch content from a given surrogate
  - DNS
  - HTTP redirect
  - Explicitly configured proxy
  - "transparently" intercept requests
- CDNI requires co-operation among CDN providers in this step
- Can think of this as two-phases:
  - Select the CDN
  - Select the surrogate in the CDN

Request Routing Requirements

- Content owner controls which CDN or CDNs are the "top level" CDNs
- Client needs ultimately to be directed to a "leaf" CDN that
  - Has the content, or can get it
  - Can deliver it with suitable latency
- Likely to be policies involved in CDN choice
  - e.g. use this CDN for clients in country X
- Within a given CDN, selection of the exact surrogate best done by that CDNs policies/ algorithms

Content distribution

- To get a piece of content that is stored in CDN A delivered by CDN B, those CDNs need a common name for the content
  - Is that a URL or something more specific?
  - The fact that URLs have embedded DNS names is a drawback
- CDN A either tells B that it has the content a priori ("put" model) or CDN B asks CDN A when it needs it ("get" model)
- In richly connected topology (think Internet AS graph) these puts and gets need to be routed

CDNI Accounting

- Each CDN needs to collect records (eg W3C Transaction Log) for each transaction it served incl:
  - Client IP
  - Start/stop time
  - Quality indicators (rate/resolution …)
- CDN needs to (aggregate? and) export to PHOP CDN all records for assets associated with that PHOP CDN comprising:
  - Records for deliveries performed by that CDN (*)
  - Records for deliveries performed by downstream CDNs on behalf of that CDN

(*) with disambiguation between deliveries to an end-user vs delivery to the Downstream CDN

CDN Interconnect - Summary

- Set of technologies allowing many CDNs to operate as a "single big CDN"
- Content Publisher can leverage CDN infrastructure from all CDN Providers while only establishing relationship with 1 (or a few) Tier-1 CDN Provider(s)
- Need for standardized interfaces, redirect mechanisms, etc.
- Accounting + Settlement allows CDN Providers to get compensation proportionate to their contribution towards better delivery
  - Money can flow in multiple directions
- Should facilitate wide range of business models, not bake one in, e.g.
  - "PSTN Call Termination Model"
  - Per view, per user, per CDN
  - Settlement-free, etc.