# Network Positioning System

*How service provider infrastructure can support rapid growth of video, cloud and application traffic*

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# Network Positioning System Abstract

- Service Providers are seeking to make efficient use of their network infrastructures and, at the same time, are seeking to support the rapid deployment of new services and applications.
- These trends are driving closer integration between applications & services and the IP/MPLS transport network.
- In this presentation we consider the new technologies that are enabling application and service aware IP/MPLS (v4/v6) networks to meet these goals, with use cases illustrating how they are practically used in Service Provider networks.

# Introduction and Overview

# Application and Service Aware IP/MPLS Network

- Historically there has been loose coupling between the network and applications and services that use the network
- The network reacts to application and service demands

Longer term processes

Shorter term processes

- *Network design* aims to support the forecasted traffic demands of applications and services
- *Capacity planning* aims to ensure there is sufficient capacity provisioned to supported projected traffic demand growth
- *Traffic Engineering* may be used to ensure that the provisioned capacity is efficiently used

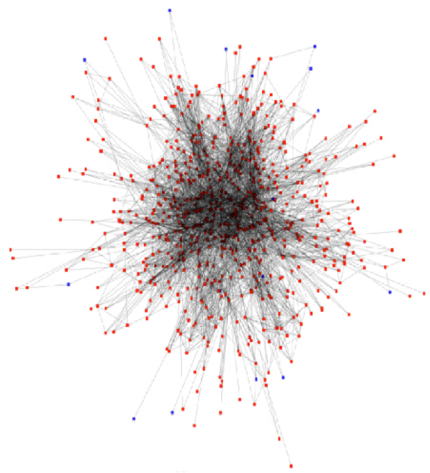
# Problem Statement

- Current application overlays do not have direct awareness of the network infrastructure when dealing with service location and service placement
  - SPs are understandably sensitive about exposing topology information
  - Current application mechanisms: delay measurements, DNS, anycast, …
- High bandwidth, high volatility applications expose the limitations of this approach
  - Can make inefficient use of network resources, i.e. incurring additional cost
  - May not be able to deliver required SLAs
  - May not meet network policy requirements
- Karagiannis et al [1] show that traffic generated by popular peer-to-peer applications often crosses the same network boundaries multiple times, contributing to congestion at network bottlenecks [2]
  - “ ...up to 70-90% of existing local content was found to be downloaded from external peers.”

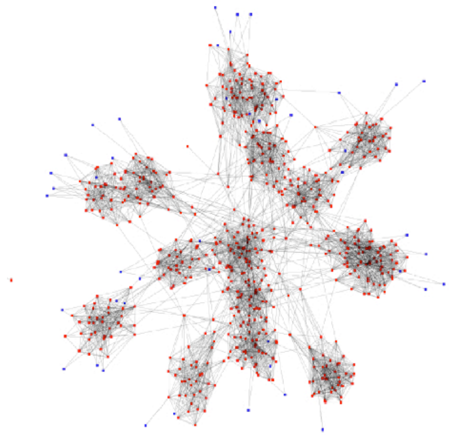
[1] Karagiannis, T., Rodriguez, P., and K. Papagiannaki, "Should ISPs fear Peer-Assisted Content Distribution?", ACM USENIX IMC, Berkeley 2005.
[2] Akella, A., Seshan, S., and A. Shaikh, "An Empirical Evaluation of Wide Area Internet Bottlenecks“, Proceedings of ACM SIGCOMM, October 2003

# Benefits of closer coupling

- When the overlay topology is network aware, it is highly correlated with the underlying network topology; the nodes within an AS form a dense cluster, with only a few connections going to nodes in other AS [3]
- Comcast's experience:
  - *"... reduced outgoing Internet traffic by an average of 34% at peering points."*
  - *"... reduced incoming Internet traffic by an average of 80% at peering points."*



Network Unaware



Network Aware
(Overlay-underlay
Topology Correlation)

[3] Aggarwal, V., Feldmann, A., and C. Scheideler, "Can ISPs and P2P systems co-operate for improved performance?", ACM SIGCOMM Computer Communications Review (CCR), 37:3, pp. 29-40.

[4] C. Griffiths, J. Livingood, L. Popkin, R. Woundy, Y. Yang, "Comcast's ISP Experiences in a Proactive Network Provider Participation for P2P (P4P) Technical Trial", RFC 5632, September 2009

# Enabling Technology: ALTO, NPS

- ALTO (being defined in the IETF)
  - Application Layer Traffic Optimization (ALTO) defines an interface through which an application can request guidance from the network, e.g. which can be used for service location or placement

    No need to know atomic topology details

    Need to preserve confidentiality between layers
  - ALTO does not define the mechanisms used for deriving network topology/ infrastructure information or preference
- NPS
  - Network Positioning System (NPS) is a specific implementation of mechanisms and algorithms leveraging routing and IP/MPLS infrastructure layer database (such as ALTO), performance, and policy information

# Demand Engineering

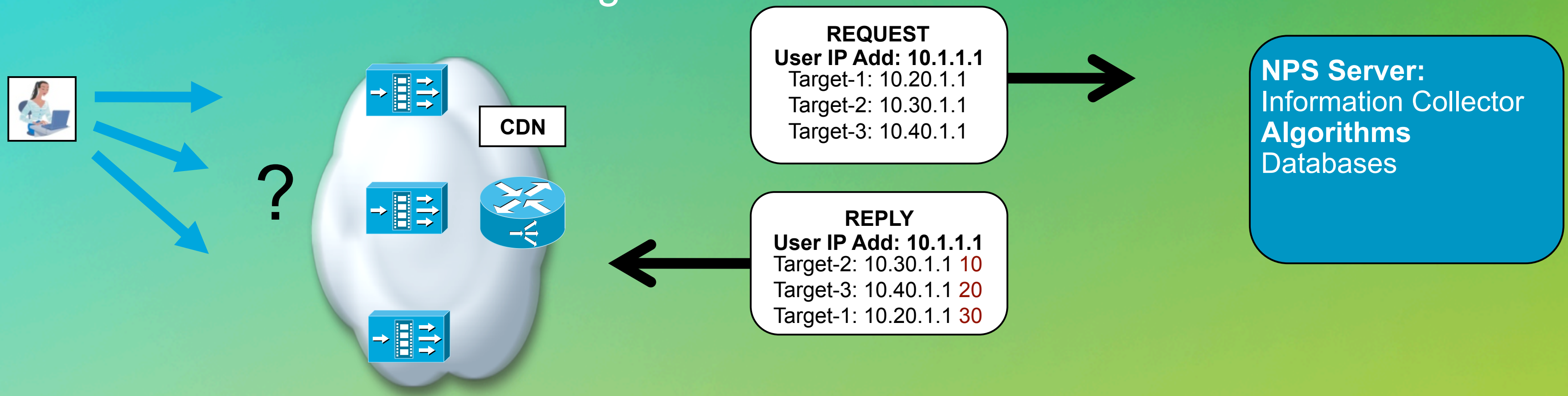
- ALTO / NPS enable network aware demand engineering
  - Overall goal is to improve application Quality of Experience while optimising resource consumption in the underlying network infrastructure
- Ensures that SLA requirements for these services can be met
  - Network cost
  - Network performance {delay, jitter, loss, availability}
  - Network capacity {admission control}
  - Geo-location derived from network location
  - Network policy
- Maximises the demands that can be serviced by placing demands where there are available network resources
  - Goal: minimise maximum utilisation
  - Enables optimisation beyond what can be achieved with traffic engineering alone

# NPS Introduction

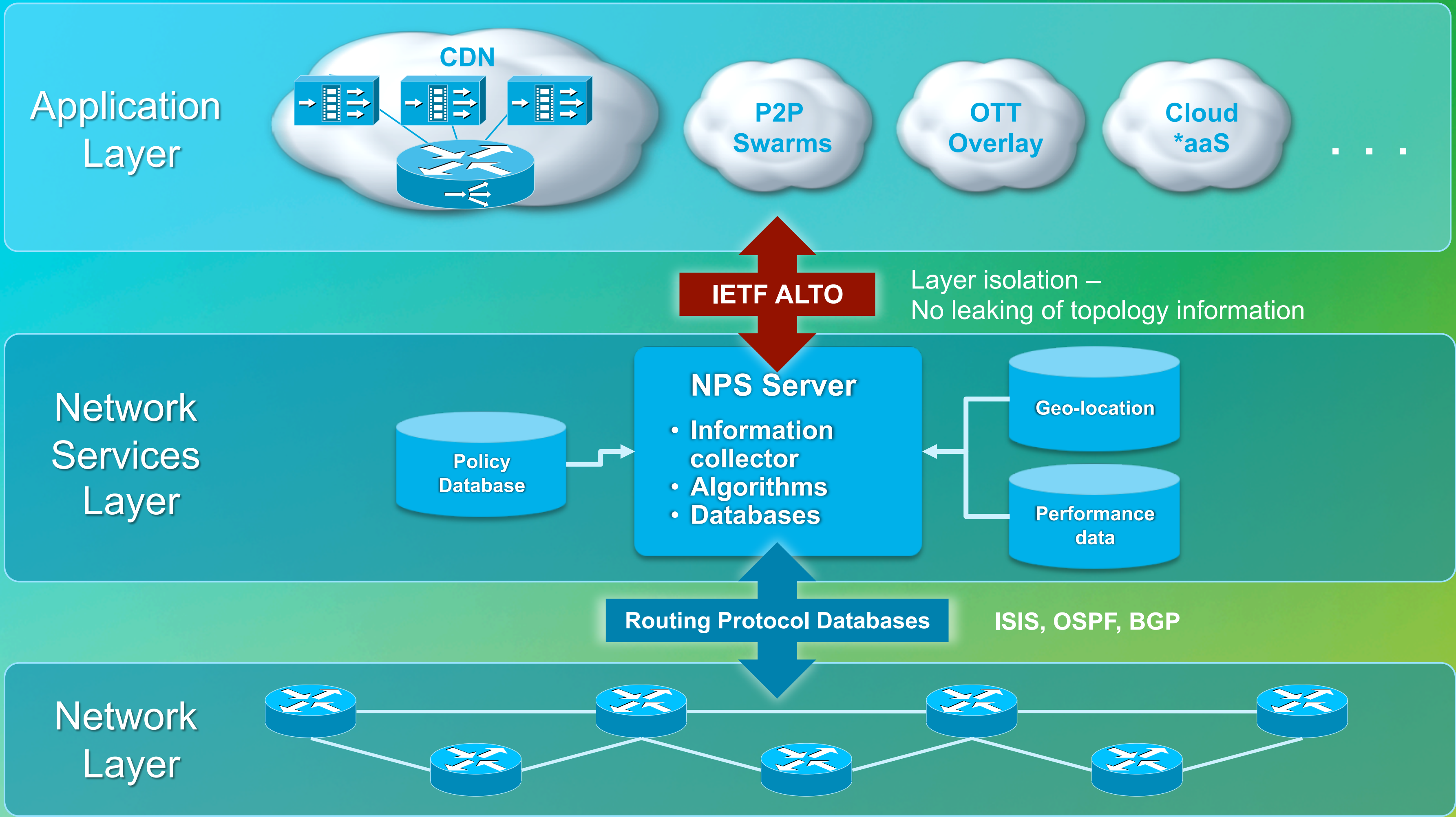
- **What**: Network Positioning System (NPS, aka Proximity) computes the location of and distance between endpoints.
  - Shipped and deployed implementation: CDS-IS Service Router
  - Work In Progress Implementations: CRS/CGSE, ASR1K
- **Why**: Caching and replication are vital to optimization of network traffic. Distribution paradigms efficiency is augmented by dynamic mechanisms that locate (and determine distance to) services and data in order to optimize infrastructure resources utilization.
  - Example: need to locate the nearest copy of a movie or the closest instance of a service among several available resources
- **How**: NPS leverages infra/routing layer and policy information.
  - Extensible to other information sources such as: state & performance and Geo-location

# Network Positioning System Service Delivery

- “Keep It Simple” approach:
  - When CDN has to select content location for user, it asks NPS first
  - Then, CDN includes NPS hint in selection process
- Request Reply Model: Address Ranking
  - Which targets in a given list of IP addresses are the closest to a particular query source (e.g.: user IP address) ?
  - Simple location & distance request by application to network
  - Extensible to other ranking criteria



# NPS Architecture – Layer Separation

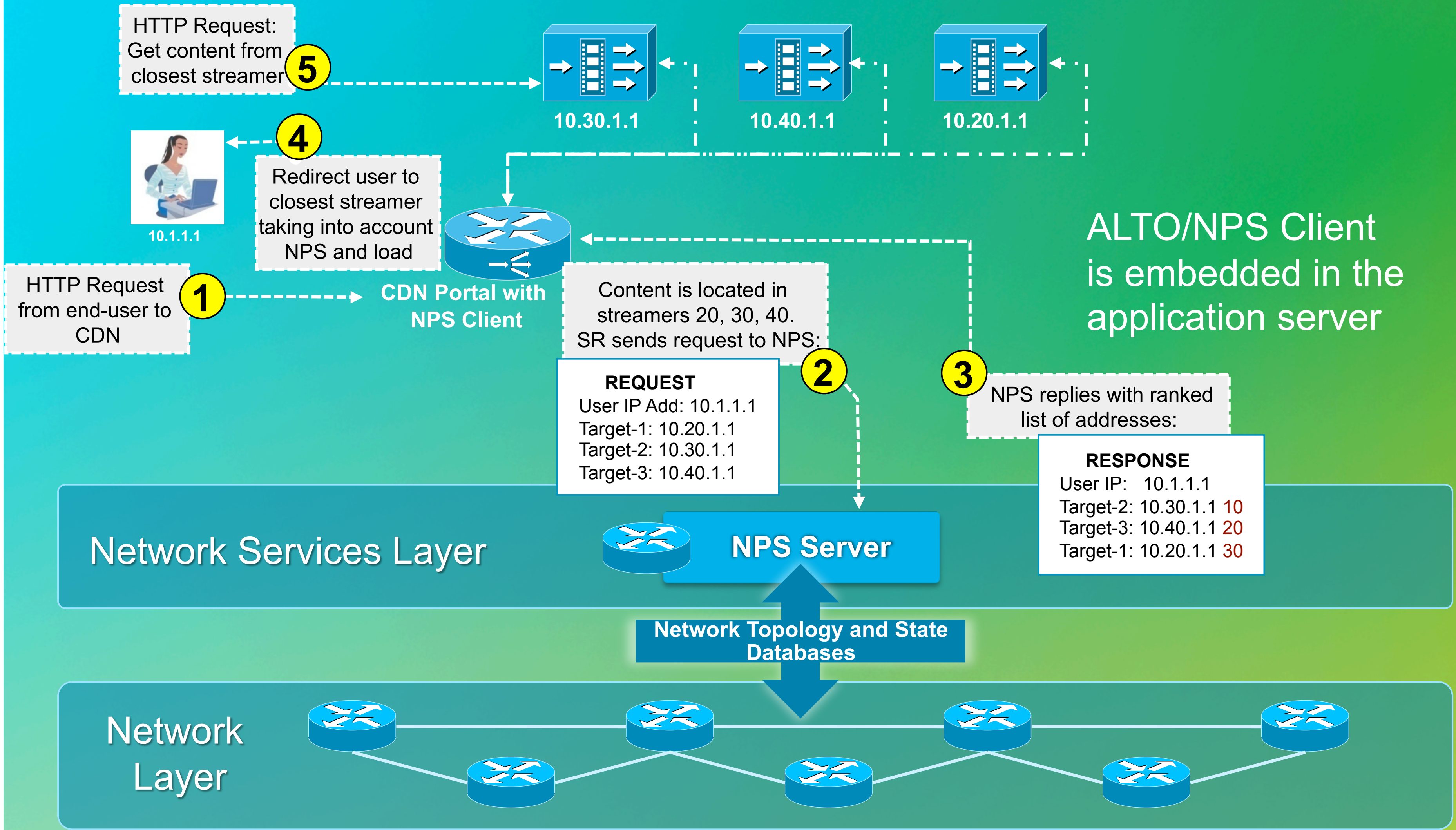


# NPS: One Service Many Applications

| Appl | Description | Use Case |
|---|---|---|
| NaaS | NPS/Proximity as a Service | Customer intends to offer NPS as a service to its' customers |
| NaaT | NPS/Proximity as a Tool | Customer intends to use NPS as a tool to enhance its current CDN or current proximity-like algorithms. |
| CDNS | CDN Selector | NPS/Proximity to select between different CDNs |
| CDS-IS | Content Distribution System-Internet Streaming | Customer intends to deploy CDS-IS from VCPBU and run NPS/Proximity piece on CRS |
| CCN/IaaS | Cloud Centric Networking / Infrastructure-as-a-Service | Customer intends to offer Cloud VPNs/Infrastructure as a Service to its' customers |
| P2P | Peer-to-Peer streaming optimization | Customer wants to ensure that P2P traffic makes efficient use of network topology thereby reducing uplink/peering costs |
| NaNPS | NPS+CGN | Customer uses NPS on CRS to connect clients & servers across private&public address space |
| NPSv6 | NPS+IPv4/IPv6 XLAT | Customers uses NPS on CRS to connect clients&servers across address family domains |

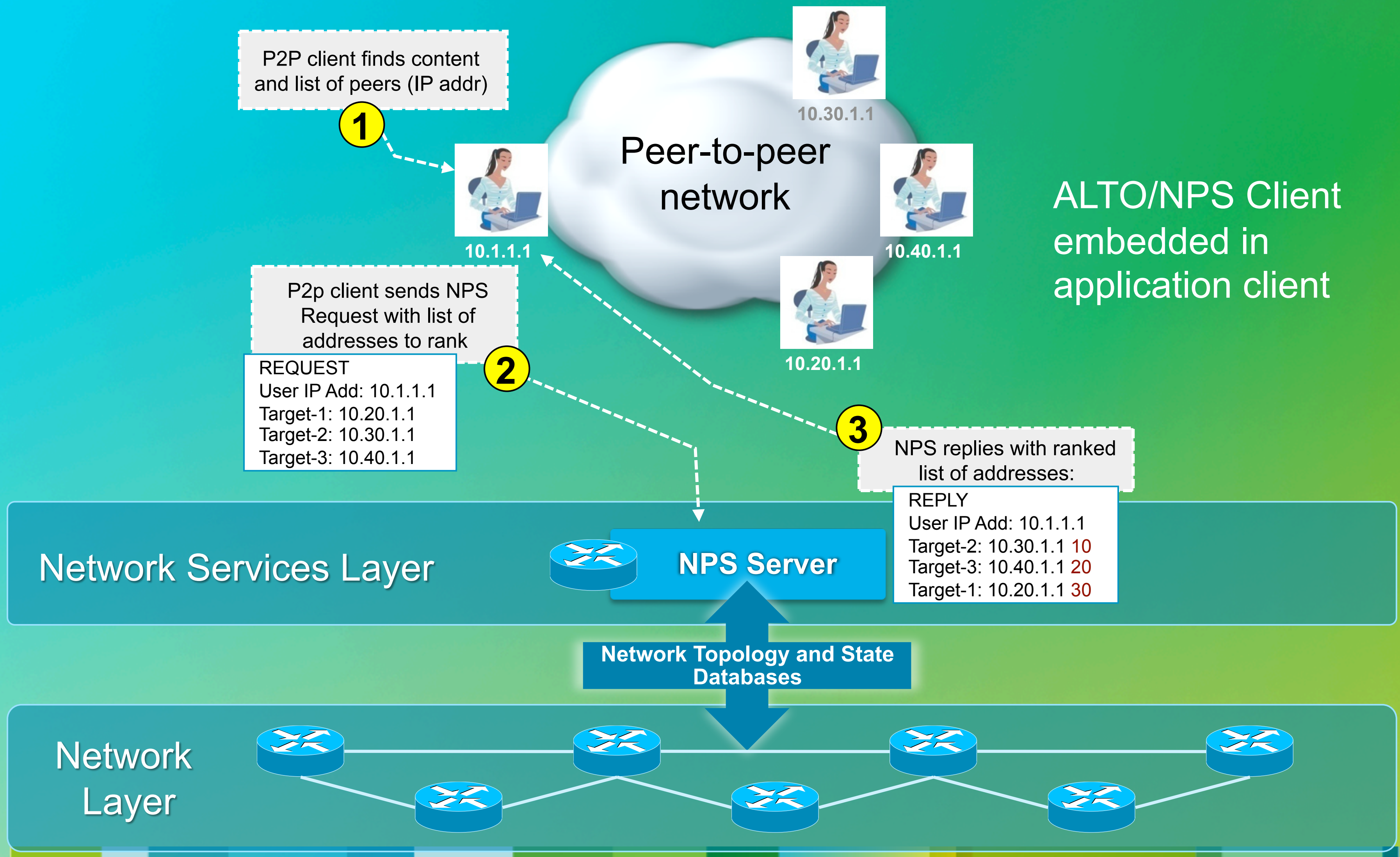
# NPS Service Applicability

# Use Case: Content Delivery Network



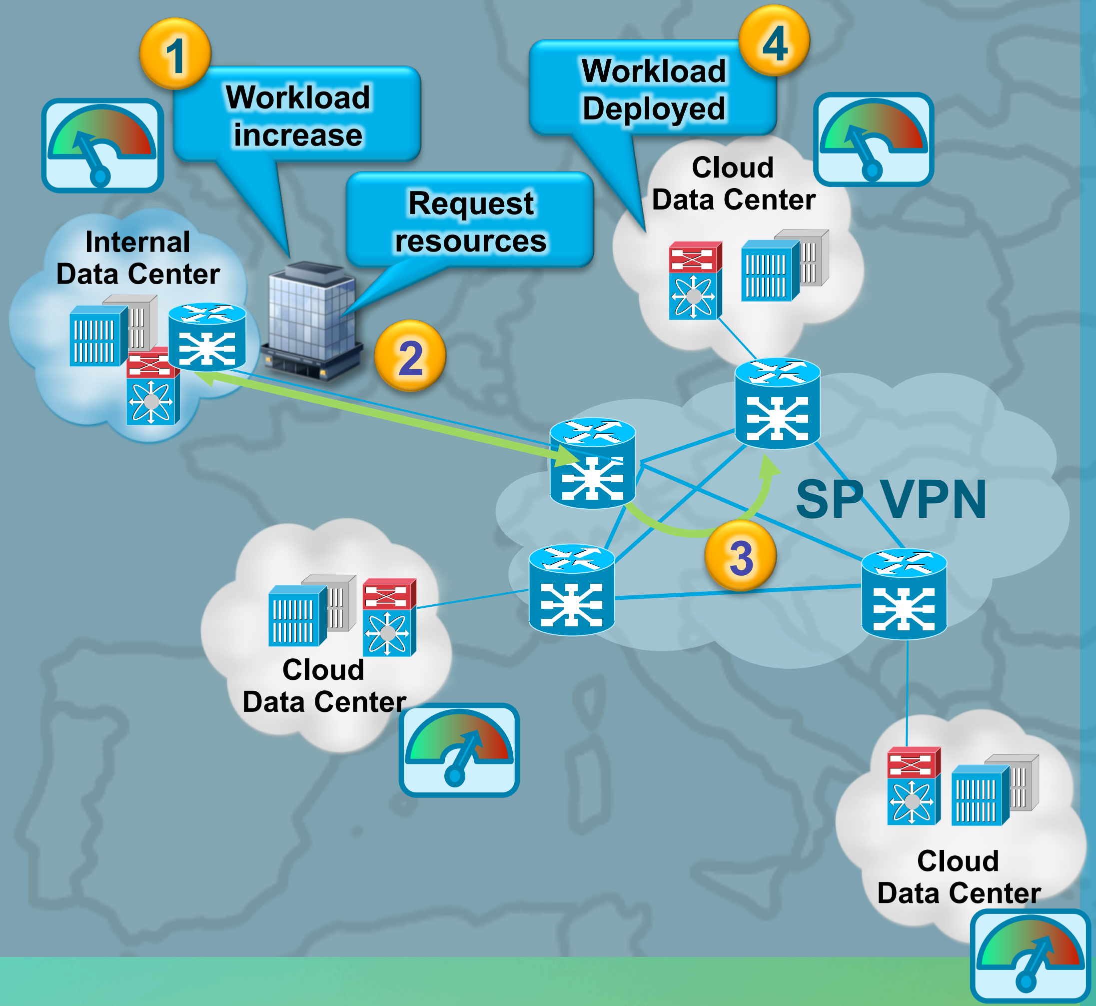

ALTO/NPS Client is embedded in the application server

# Use Case: Peer-to-peer overlays




ALTO/NPS Client embedded in application client

# Cloud Centric Networking: Cloud Computing IAAS

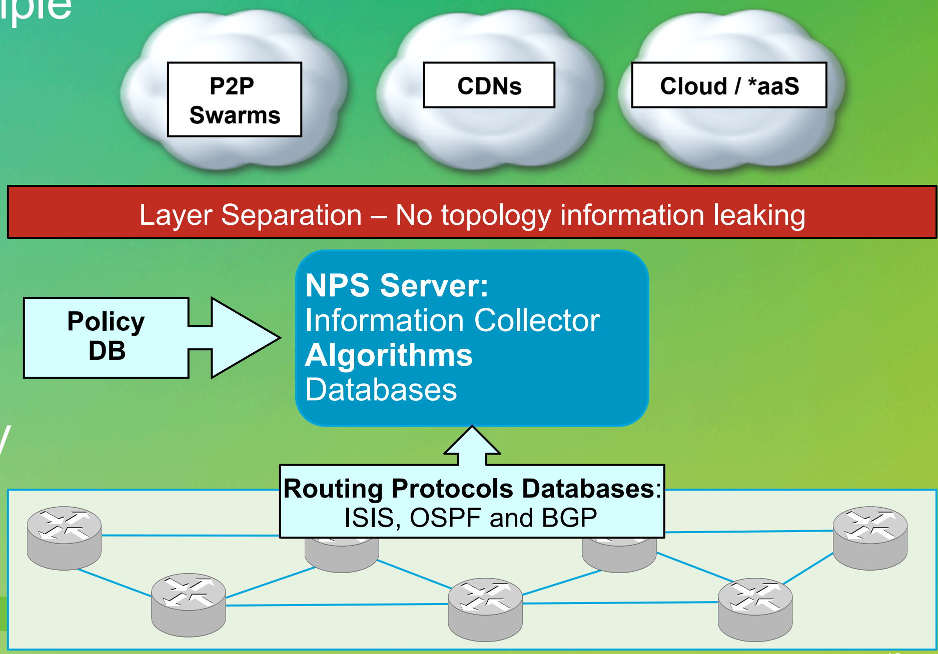



1. Additional capacity needed – request cloud resources
2. Check resource availability, performance – determine optimal location
3. Provision network tenant, virtual compute, storage, VPN, services
4. Virtual infrastructure and network container active

# NPS Implementation

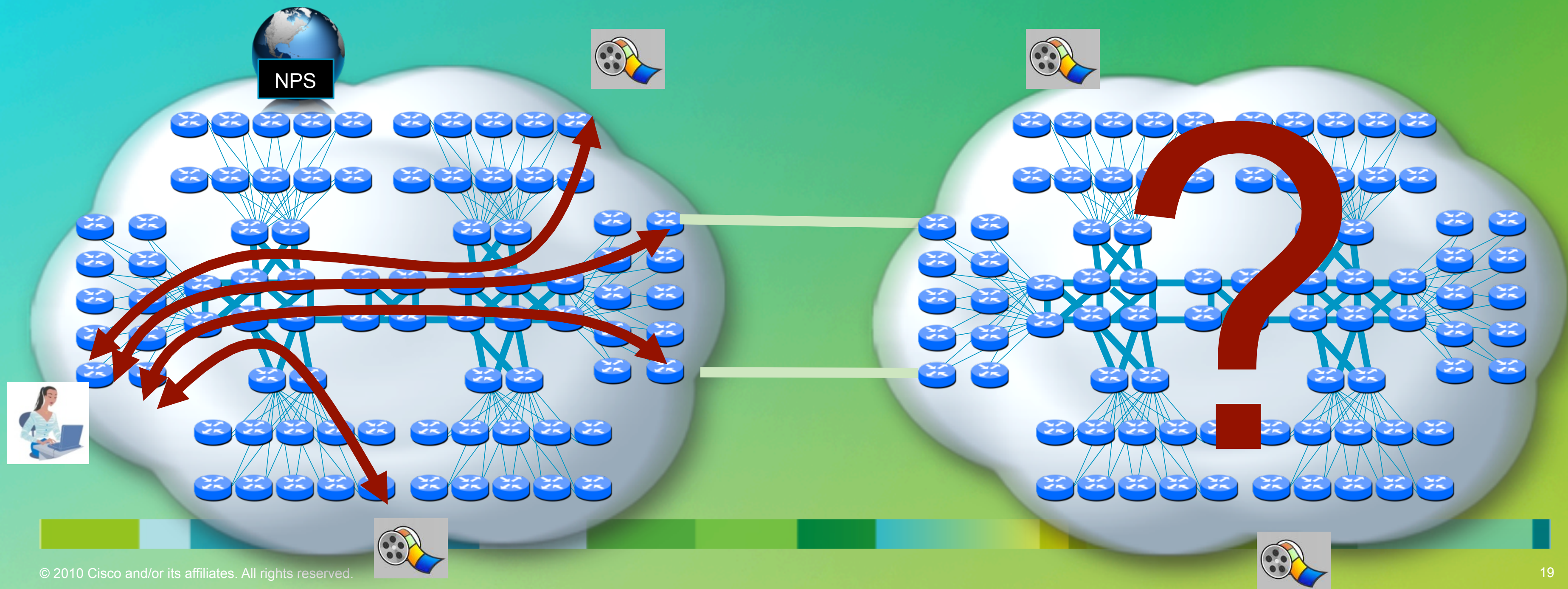
# Network Positioning System Technology

- How to determine location and distance ?
  - Topology: Routing Databases (IGP/BGP)
  - Policy: Prefix Groups / BGP Communities
  - Cost/weight between group of prefixes (communities)
- How to best rank addresses ?
  - Aggregate/combine results from multiple algorithms (routing, policy, groups)
- How to ensure security & confidentiality between application and network layers?
  - No information is leaked in either way
  - Clear layer isolation



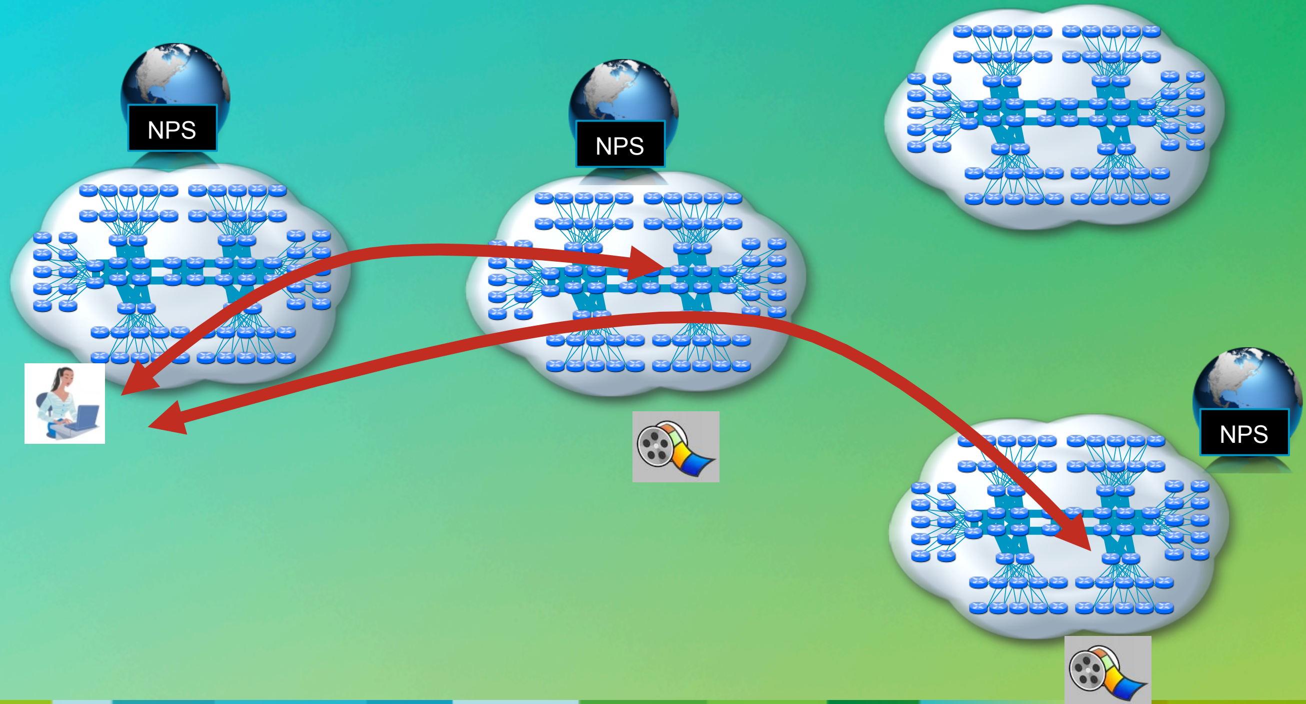
# Network Positioning System: Routing Proximity Algorithms

- IGP based NPS Proximity algorithm leverages IGP link-state information and determines optimal choice for least impact on backbone infrastructure
  - IGP choice: prefer target with closest exit point
- Extensions to routing algorithms as used in the routing layer
  - NPS extensions for NPS purpose: traffic direction, selection process



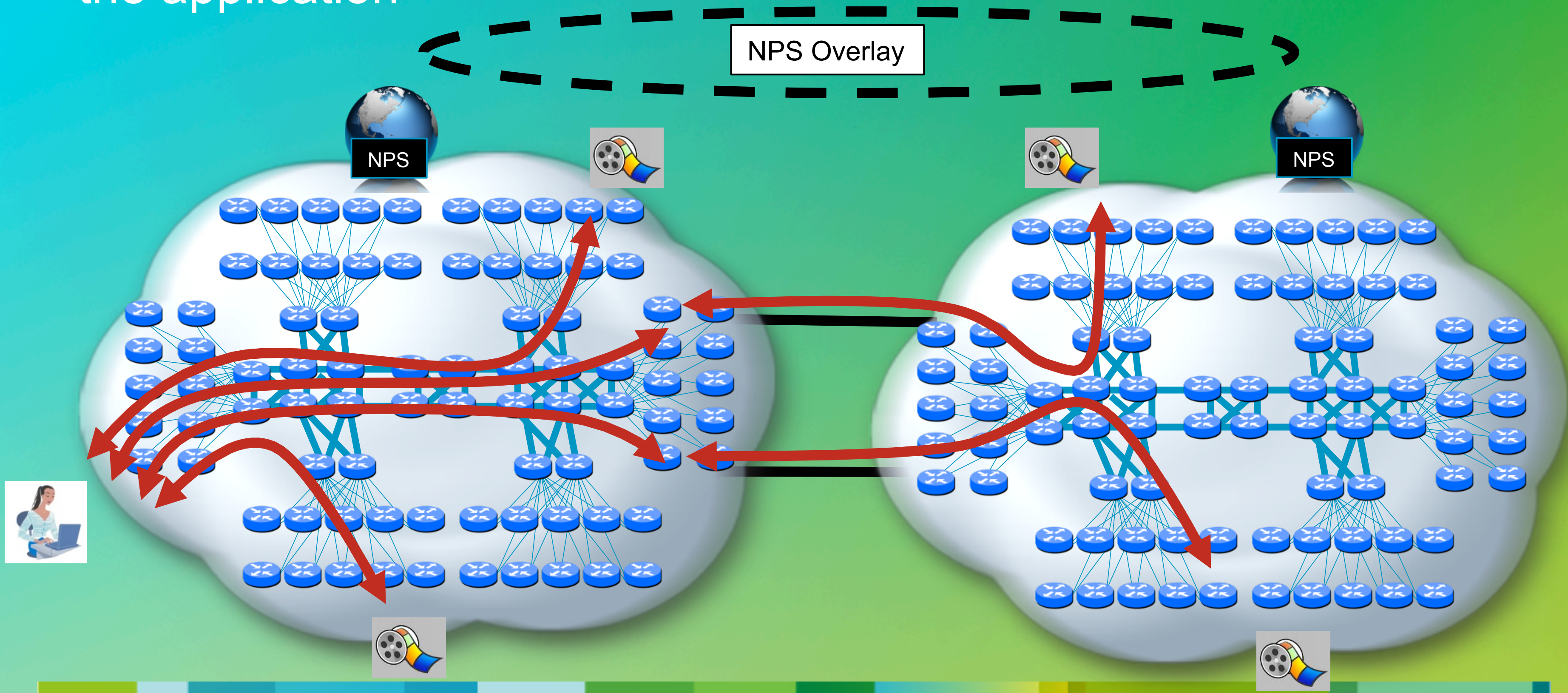
# Network Positioning System: Routing Proximity Algorithms

- BGP based NPS Proximity algorithm leverages IGP and BGP information and determines optimal choice based on both backbone infrastructure and inter-AS policies
- BGP Policy mechanisms used by NPS to determine best location



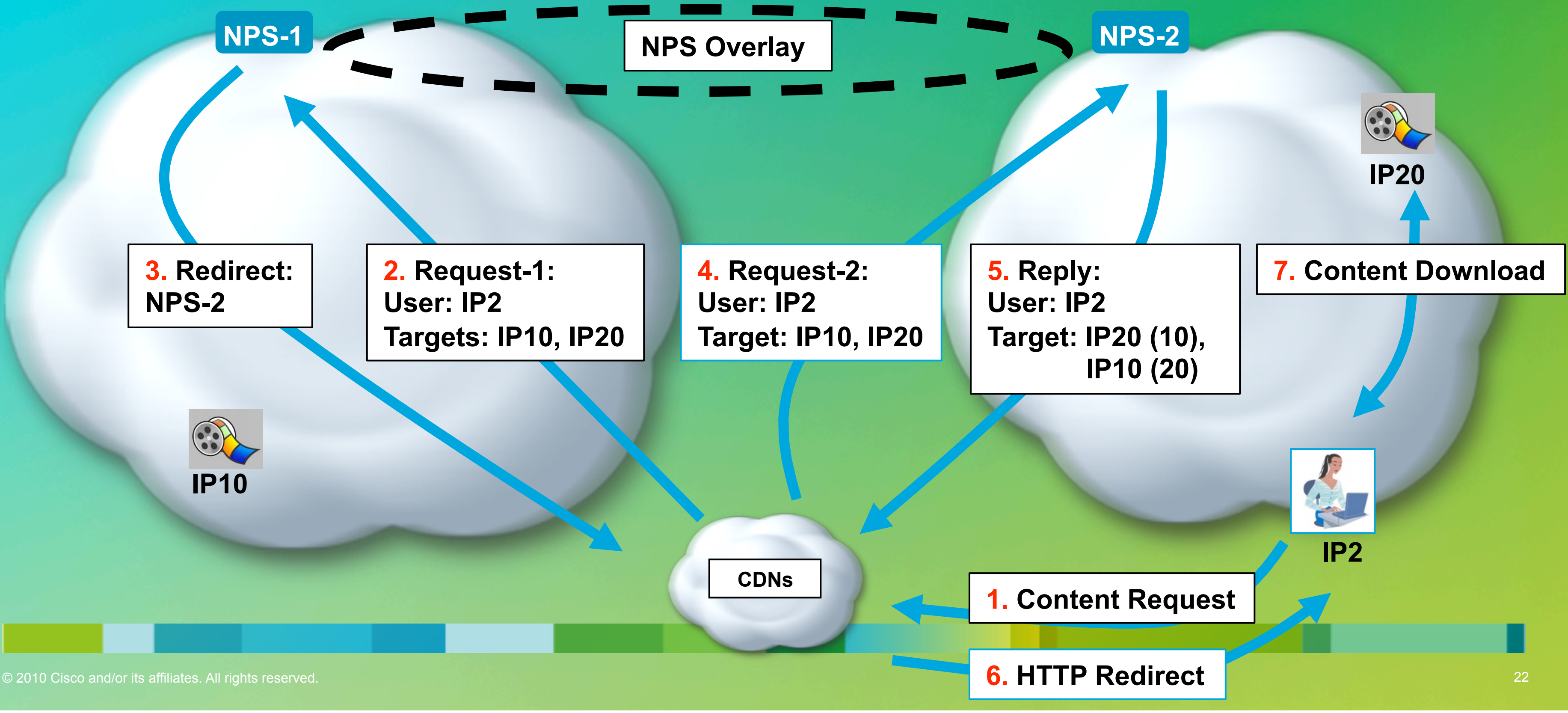
# Network Positioning System: Routing Proximity Algorithms

- Correlation between information sources: IGP/BGP/Policy
- Re-build the full picture of the network topology for the purpose of the application



# Network Positioning System Example: Redirection

- NPS acquires routing information from within the AS
- Requests received within the AS are locally server
- Requests received for addresses outside the AS will be re-directed  to NPS server located in addresses' AS
- NPS servers exchange info through an application overlay



# NPS Groups and Policies

# NPS: Grouping and Policies

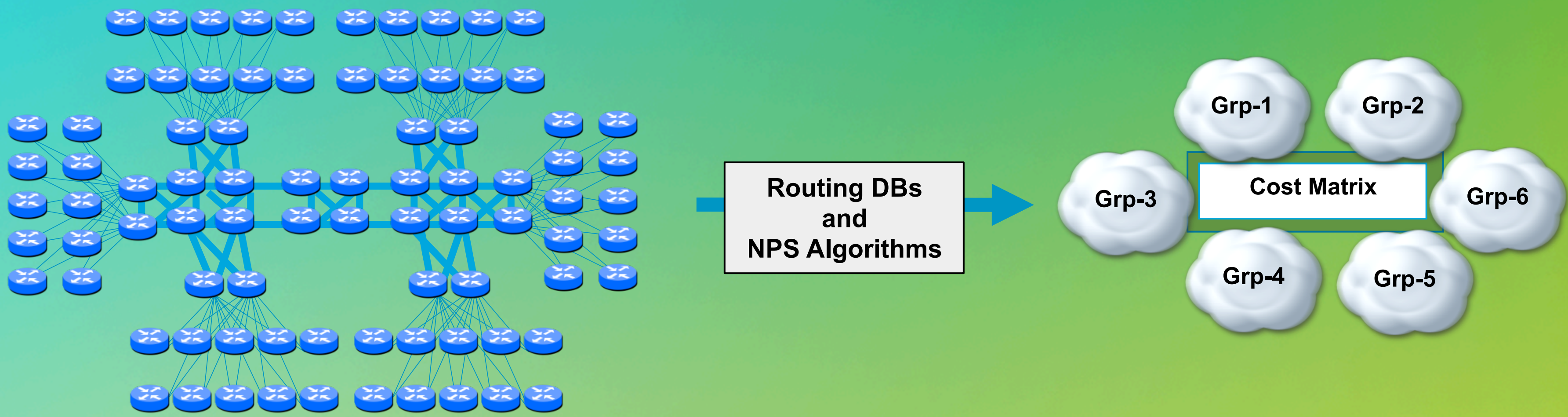
- Goals:
  - Deliver a tool for SPs to implement and deploy NPS policies reflecting existing network layer policies and applied to applications
- Routing Topology granularity of network layer makes little sense for application
  - No need to know topology atomic details
  - Need to preserve confidentiality between layers
- Scale NPS services in different application contexts
  - Deliver NPS services based on different “views” of the network according to different applications
- Two components:
  - Grouping method
  - Cost Map

# NPS: Grouping and Policies Components

- Grouping method:
  - How to efficiently group prefixes/addresses
  - SP need to define groups not corresponding to pure IP grouping methods (prefix/summary/AS)
  - Groups should be able to reflect any policy criteria:
  - Location, connectivity type, service, …
  - Grouping method should be capable of leveraging existing grouping methods deployed in SP infrastructure
- BGP Community is used by most SPs as the grouping method

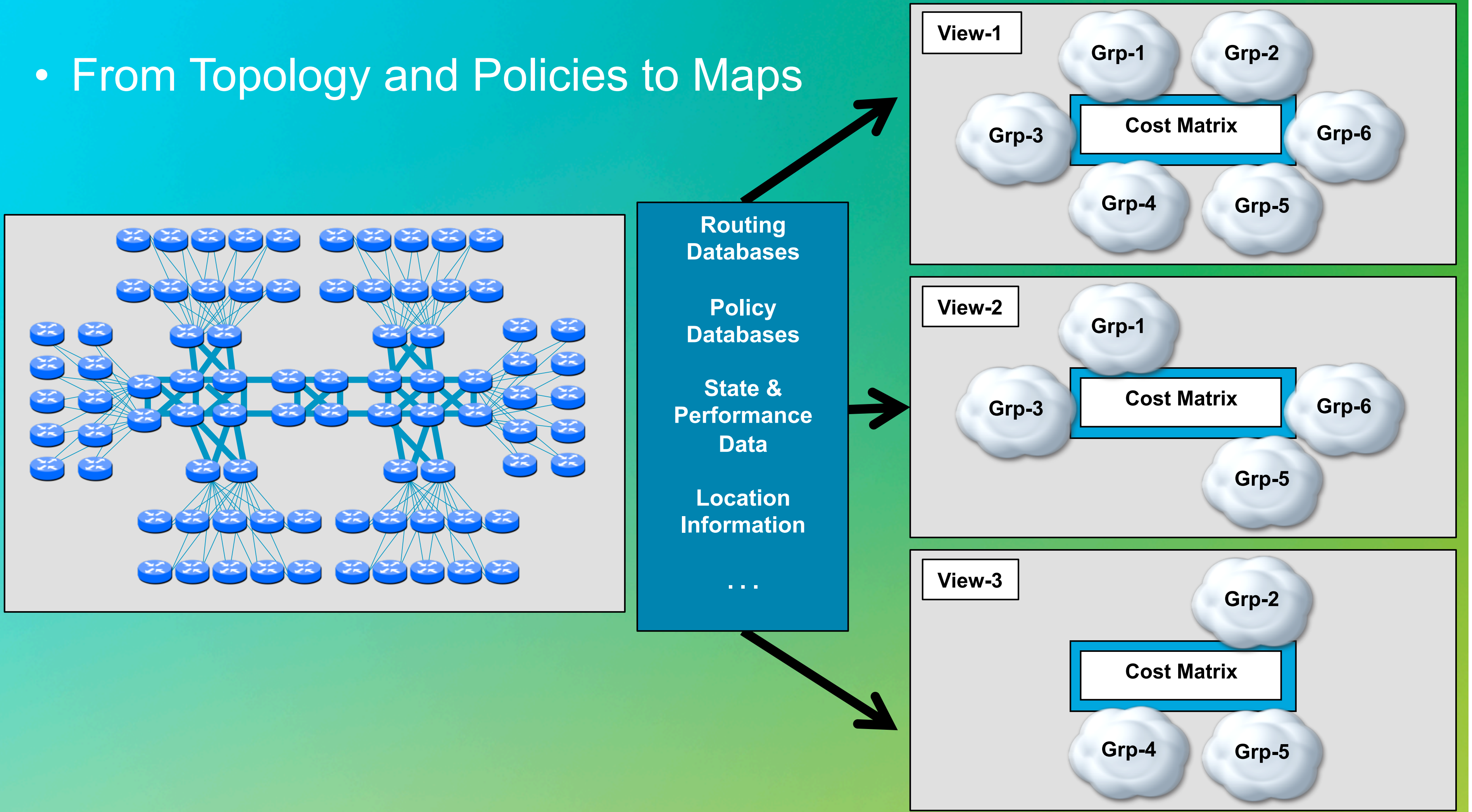
# NPS: Grouping and Policies

- From topology to groups
- Abstract level of topology
- Addresses application requirements in terms of NPS services
- Gives powerful policy control on NPS algorithms
- Dynamic and static mechanisms



# NPS: Grouping and Policies

- From Topology and Policies to Maps



# NPS Work In Progress

# NPS Enhancements

- Add NPS information sources
  - Resources Utilization
  - Performance
  - Geo-location
  - Layer-2 Topology Information
  - Service Awareness (Service Routing)
- Support of different Address-Families
  - V4/V6, VPN-V4/VPN-V6
- Integration with Routing SW

# IETF ALTO Proposals

- Currently, the IETF ALTO Working Group is working on a merged proposal with contribution from:
  - R.Yang (Yale), R.Alimi (Yale), R.Penno (Juniper), R.Woundy (Comcast), S.Previdi (Cisco), S.Raghunath (Juniper), S.Shalunov (BitTorrent), Y.Wang (Microsoft), D.Zhang (PPLive), S.M.Das (Qualcomm), L.Popkin (Pando), S.Ding (China Telecom), D.Pasko (Verizon), A.Tian (Redback), Y.Zhang (China Mobile)
  - Still under work in IETF ALTO WG

# Summary

# Network Positioning System (NPS) Summary

- NPS/ALTO is a tool SP can use in order to address the constant demand of resources from application layer
- NPS/ALTO Service consists of delivering:
  - Cost rating preferences of IP addresses/subnets
  - Reflecting topology, state, performance and policies implemented in the network
- NPS will integrate multiple network information sources in order to deliver accurate and efficient ranking services to applications
  - Dynamic: routing protocols databases
  - Policy-based: through configuration

# Network Positioning System (NPS) Summary

- NPS Client
  - Embedded into application client or
  - Embedded in application server/portal
  - Selection is improved by ranked list delivered by NPS server
- NPS Server
  - Managed by network operator
  - Interfaces with network and infrastructure layer.
  - Receives NPS Requests
  - Returns requests with ranked lists

Thank you.