CURLING: Content-Ubiquitous Resolution and Delivery Infrastructure for Next Generation Services

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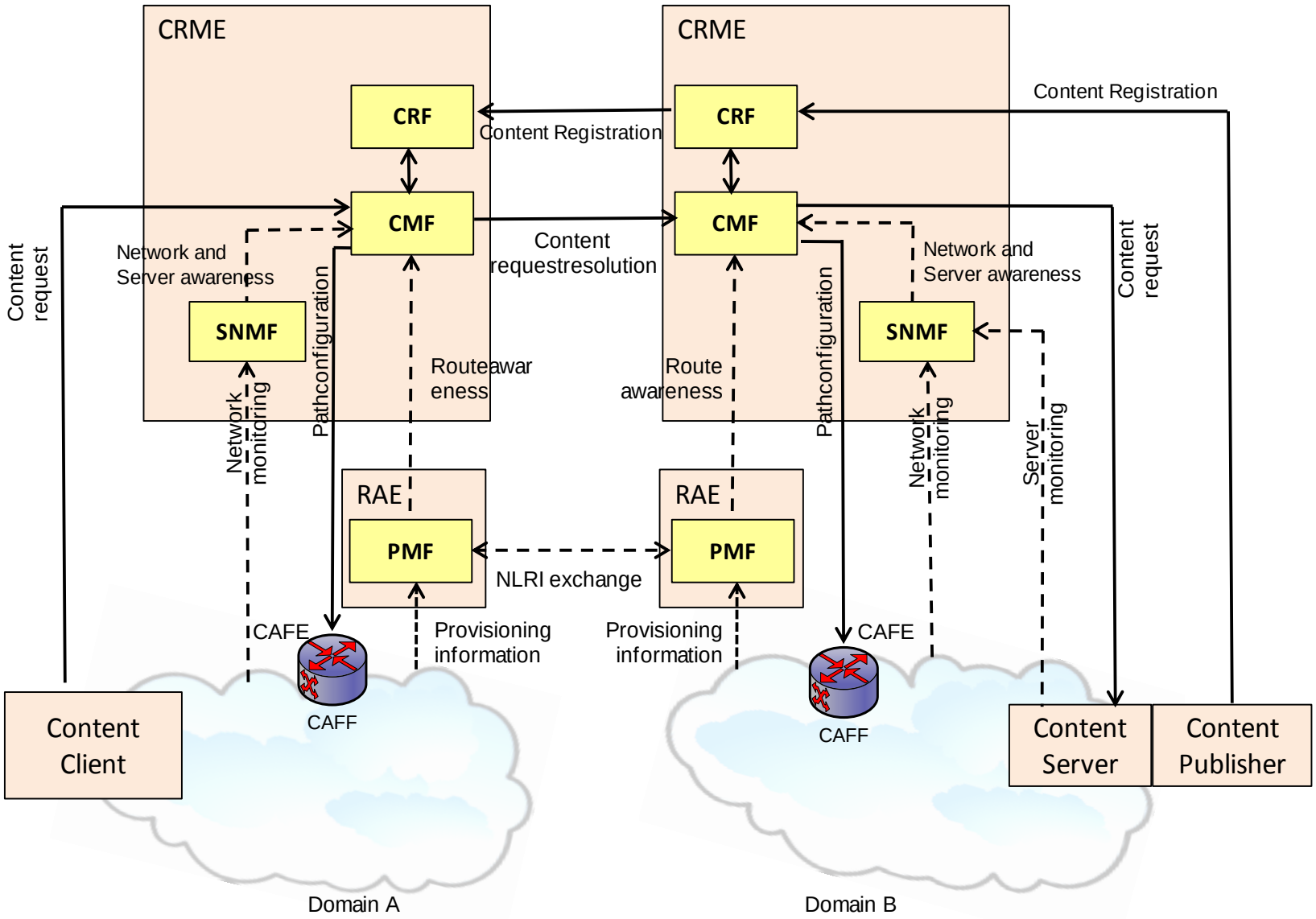
Introduction

- CURLING: An infrastructure to both accurately and efficiently ***hit*** (or ***not hit***) content objects in specific regions / areas *of the Internet.*
  - The content resolution is natively ***coupled*** with path setup.
  - Follows a domain-level ***hop-by-hop gossip-like communication model*** without revealing explicit IP address pointing to the targeted content source
  - Content resolution driven by:
    - Business relationships among ISPs (provider/customer/peer)
    - BGP route
    - Content consumer preferences
    - ISP local policies

Entities in CURLING

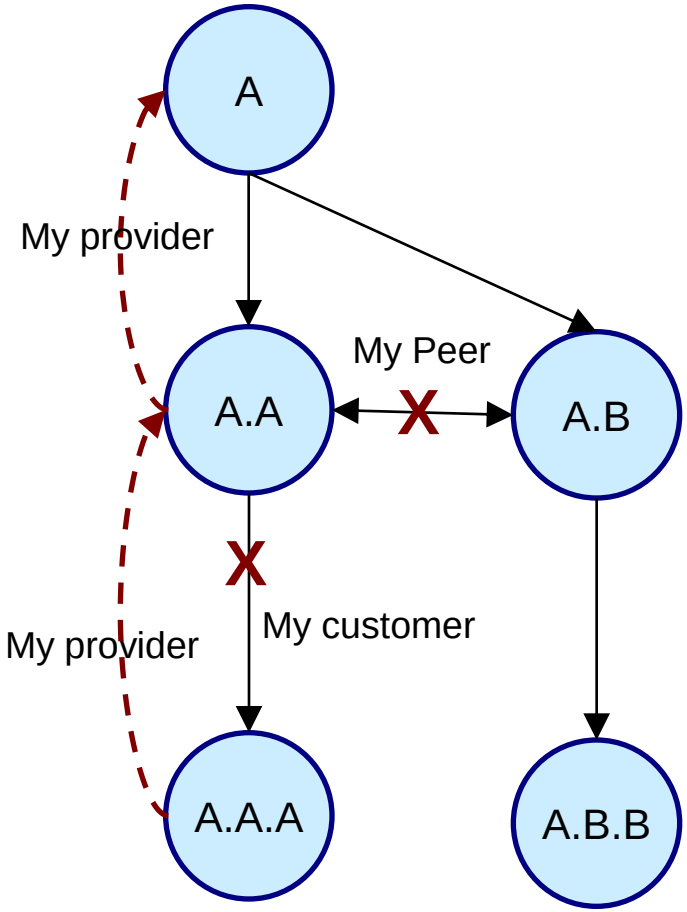


Entities in CURLING

- Main entities:
  - **Content Resolution and Mediation Entity (CRME)**
    - Resides in individual ISP
    - Collaboratively handles content publication requests, discovers requested content and supports content delivery
  - **Content-aware Forwarding Entity (CAFE)**
    - Typically edge routers
    - Collaborates with local CRME to enforce content delivery paths

Basics

- Content lifecycle
  - Content publication
  - Content resolution
  - Content delivery
- Provider route forwarding rule

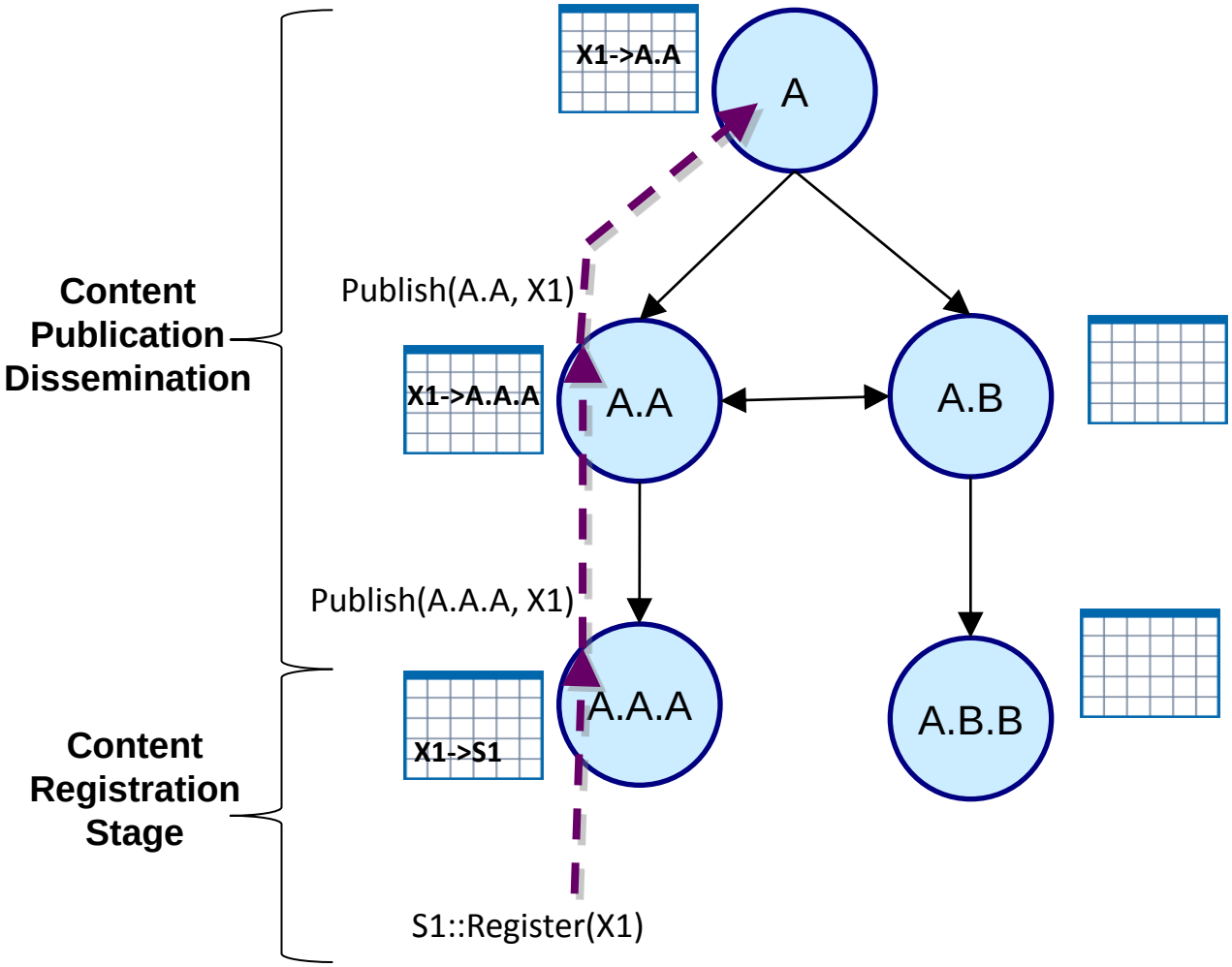


Content Publication

- Content publication – the process of making content available in the Internet
- **Stage 1**: Content registration
  - Content provider registers a new content (or a replica) to the local CRME
    - CP sends a `Register` message to the local CRME
      - with explicit location of the content (e.g., IP address of the content server)
      - And possibly with scoping option
    - Local CRME creates a new entry in the content management repository for the new content
- **Stage 2**: Content publication dissemination
  - `Publish` message dissemination strategy:

"Provider route forwarding rule"

Content Publication



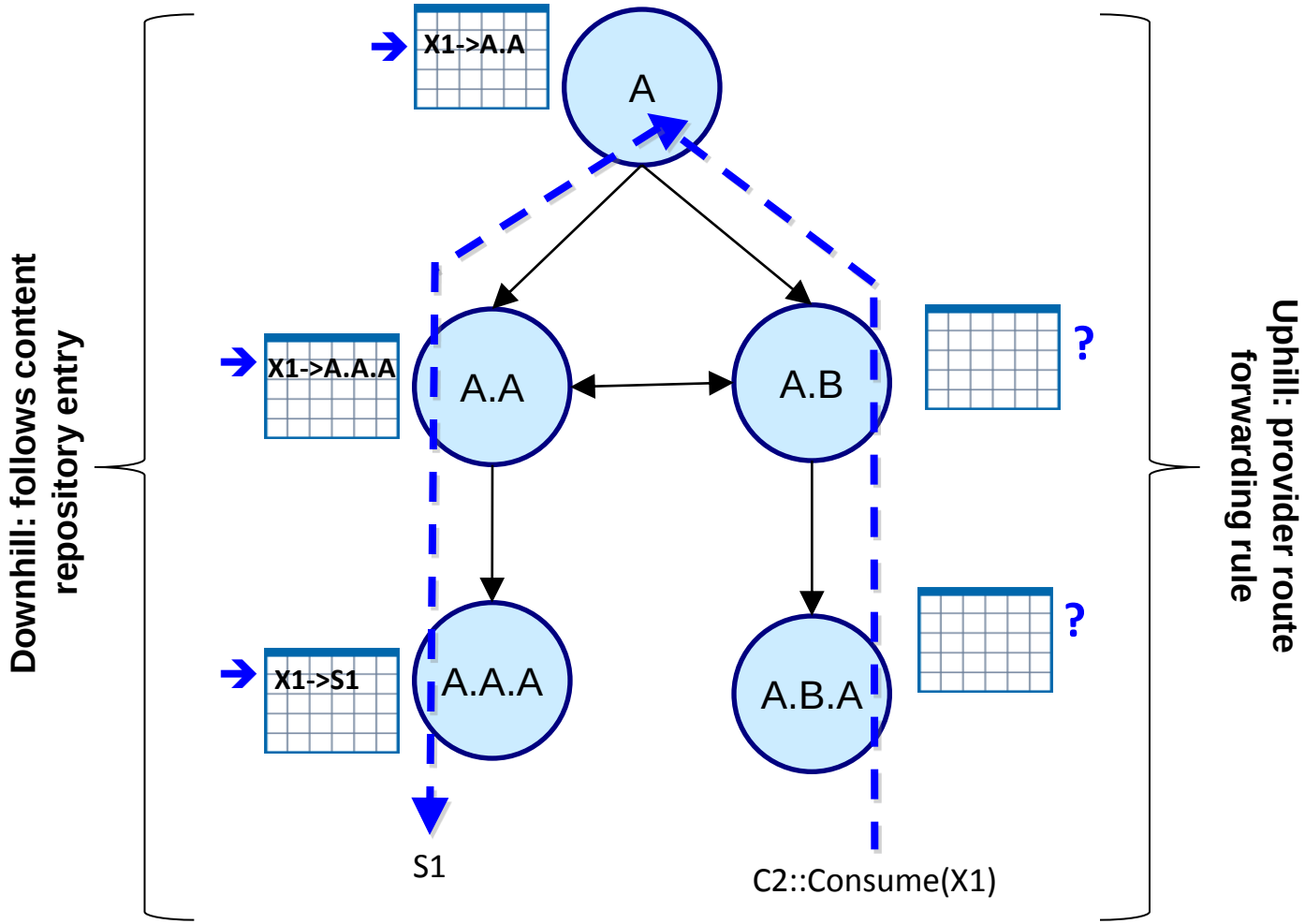
Content Publication

- Publication modes:
  - Wildcard mode
    - Content to be accessible to the entire Internet
    - Indicated by using an asterisk “*”
  - Scoped mode
    - Publication of content to specific areas in the Internet indicated by the content provider
      - E.g., BBC iPlayer are only available within UK
    - Indicated via the `INCLUDE` option in the `Register/Publish` messages

Content Resolution

- Content resolution – the process of resolving a content consumption request (i.e., `Consume`) from a content consumer by:
  - Discovering the location(s) of the requested content and
  - Delivering the request to the actual content source to initiate content transmission
- **Stage 1**: Uphill resolution
  - The forwarding of the `Consume` request up along the provider route until it reaches a CRME that has the content record entry
  - `Consume` message dissemination strategy: **provider route forwarding rule**
- **Stage 2**: Downhill resolution
  - The forwarding of the `Consume` request down from the CRME that has the content record to the explicit content server that hosts the content
  - `Consume` message dissemination strategy: follows the content repository entry

Content Resolution



Content Resolution

- Resolution modes:
  - Scoped mode
    - specific source(s) only
    - forwarding of request follows **BGP routes**
  - Wildcard mode
    - any source(s) in the Internet
    - forwarding of request follows business relationships between domains (**the provider route forwarding rule**)
  - Filtered mode
    - NOT from specific source(s); via `EXCLUDE` option
    - forwarding of request follows business relationships between domains (**the provider route forwarding rule**)

Content Delivery

- Basic features

  - The setup of content delivery paths is coupled with the corresponding content resolution paths

  - Content states are installed (by CRME) at the CAFEs located at the edge of each domain during the content resolution phase

  - **Content Forwarding**:

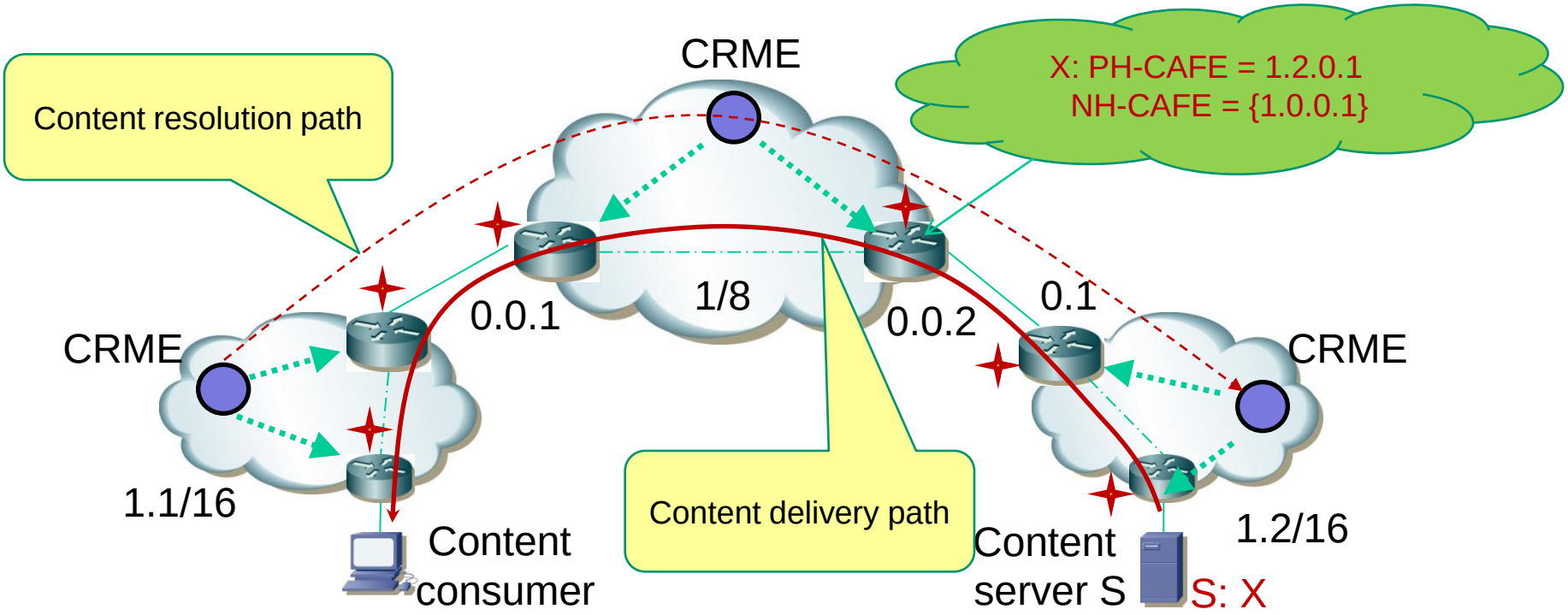
    - Content is delivered across a set of CAFEs with installed content state by local CRME
    - Interaction with native IP within each domain: either through tunnels (short-term) or following a more native approach like CCN (long-term)

- Advanced features

  - Inter-domain routing optimisation

    - Recall that content resolution operations are basically based on the business relationship between neighbouring ISPs
    - Possible shortcut content delivery paths captured from BGP routing information after the content resolution phase

CRME Interaction with CAFEs



- **CRME Functions**
  - Forwarding content resolution requests across domains
  - Configuring content states at local ingress and egress CAFEs
- NOT responsible for carrying content flows (physically decoupled from CAFE)

Content State Maintenance

• **Where** – Content states are only maintained at CAFEs that are normally planted at the network edge as ingress/egress nodes

• Core IP routers within the network are not content-aware and hence do not recognise the content identifier

•**Content forwarding rules at CAFEs (supporting inter-domain multicast)**

- Each ingress CAFE receives the content from its upstream egress CAFE in the previous-hop domain and forwards to all the local egress CAFEs which have the same state

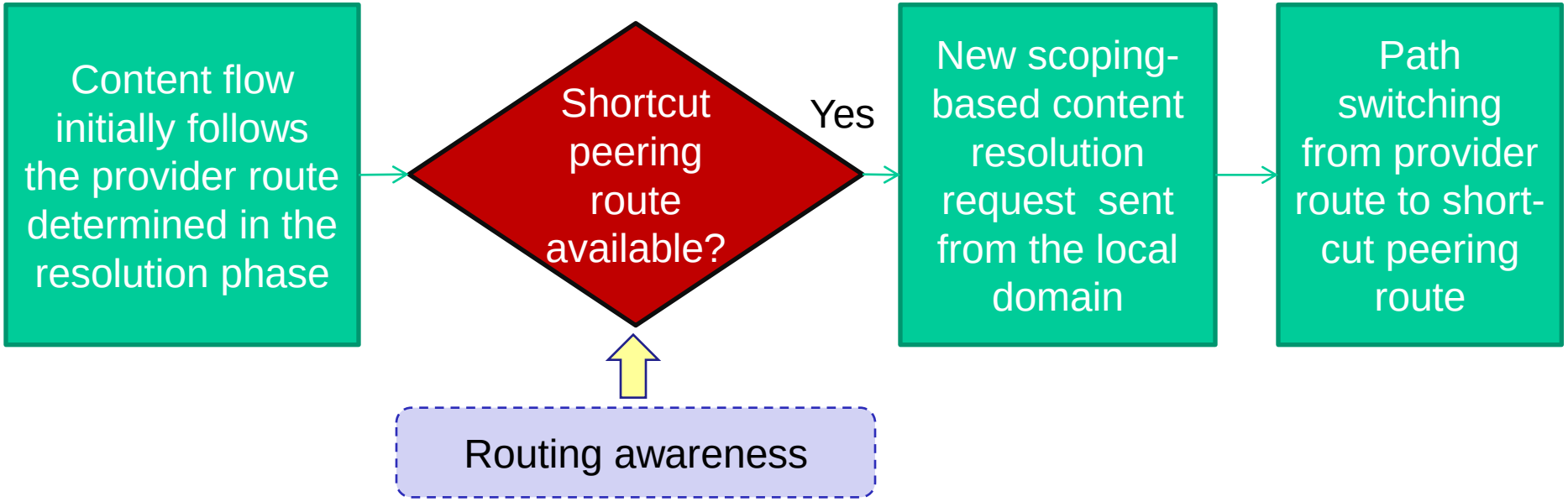
- Each egress CAFE receives the content from its local ingress CAFE and forwards to all the downstream ingress CAFEs in the next-hop domains which have the same state

Inter-domain Routing Optimisation

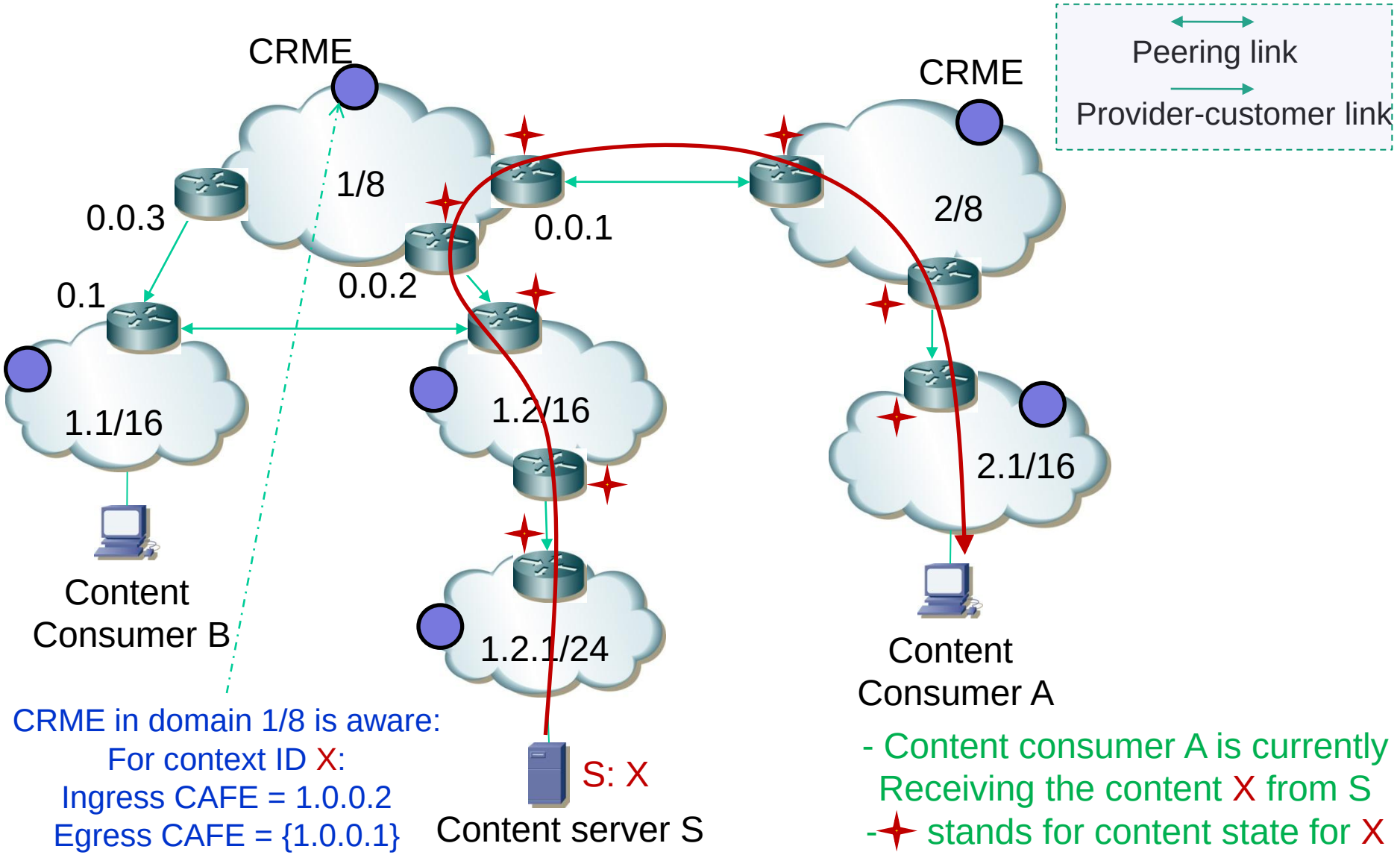
- Analogous to BGP routing policy – “prefer customer route over peering route, and ***prefer peering route over provider route***”
- Basic idea

  - A shortcut peering route (learned from BGP) is preferred over a provider route that was originally identified by the content resolution process

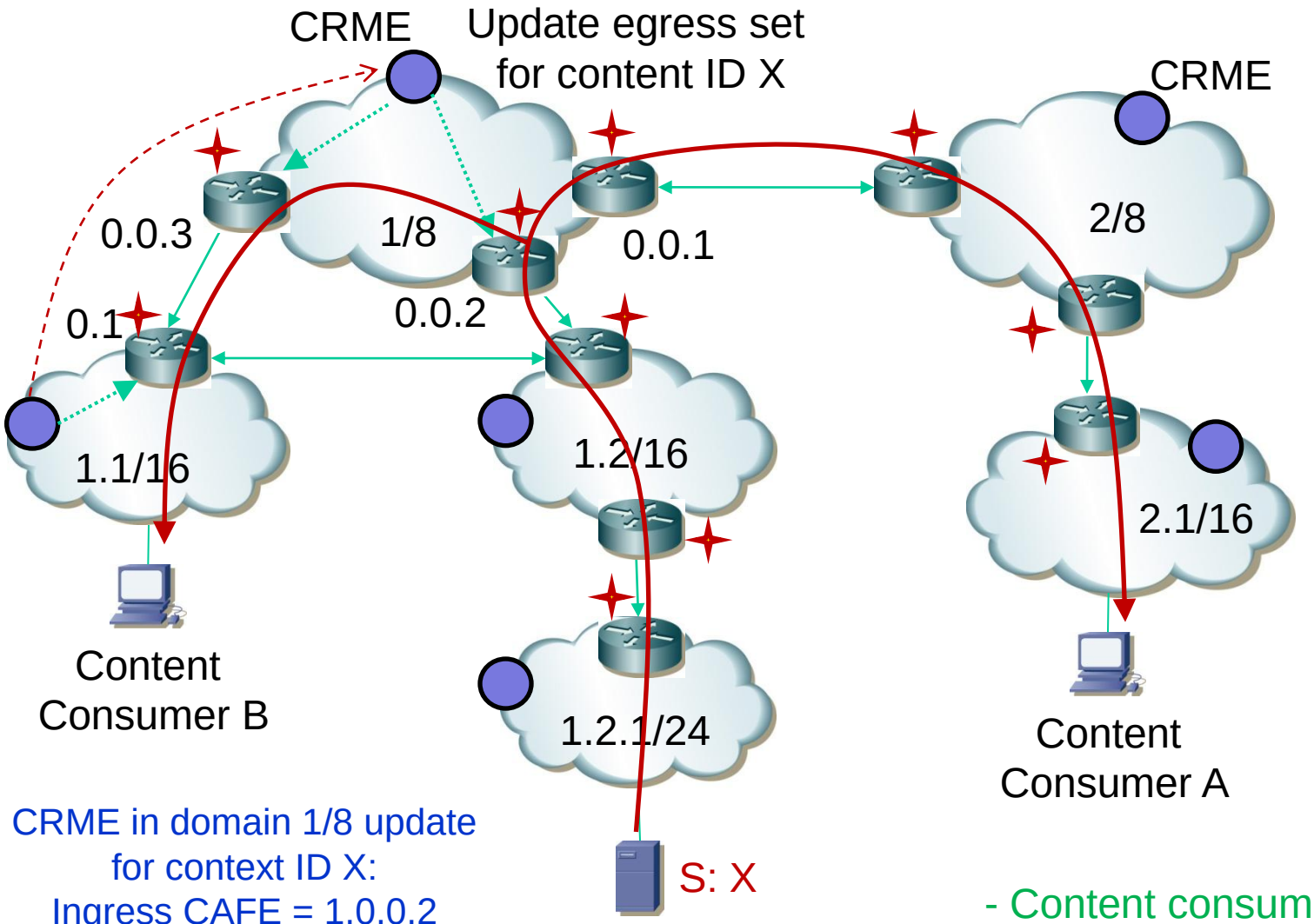
- Approach



An Example


Peering link
Provider-customer link
CRME
CRME
1/8
2/8
0.0.3
0.0.1
0.0.2
0.1
1.1/16
1.2/16
2.1/16
1.2.1/24
Content
Consumer B
Content
Consumer A
S: X
Content server S
CRME in domain 1/8 is aware:
For context ID X:
Ingress CAFE = 1.0.0.2
Egress CAFE = {1.0.0.1}
- Content consumer A is currently
Receiving the content X from S
- stands for content state for X

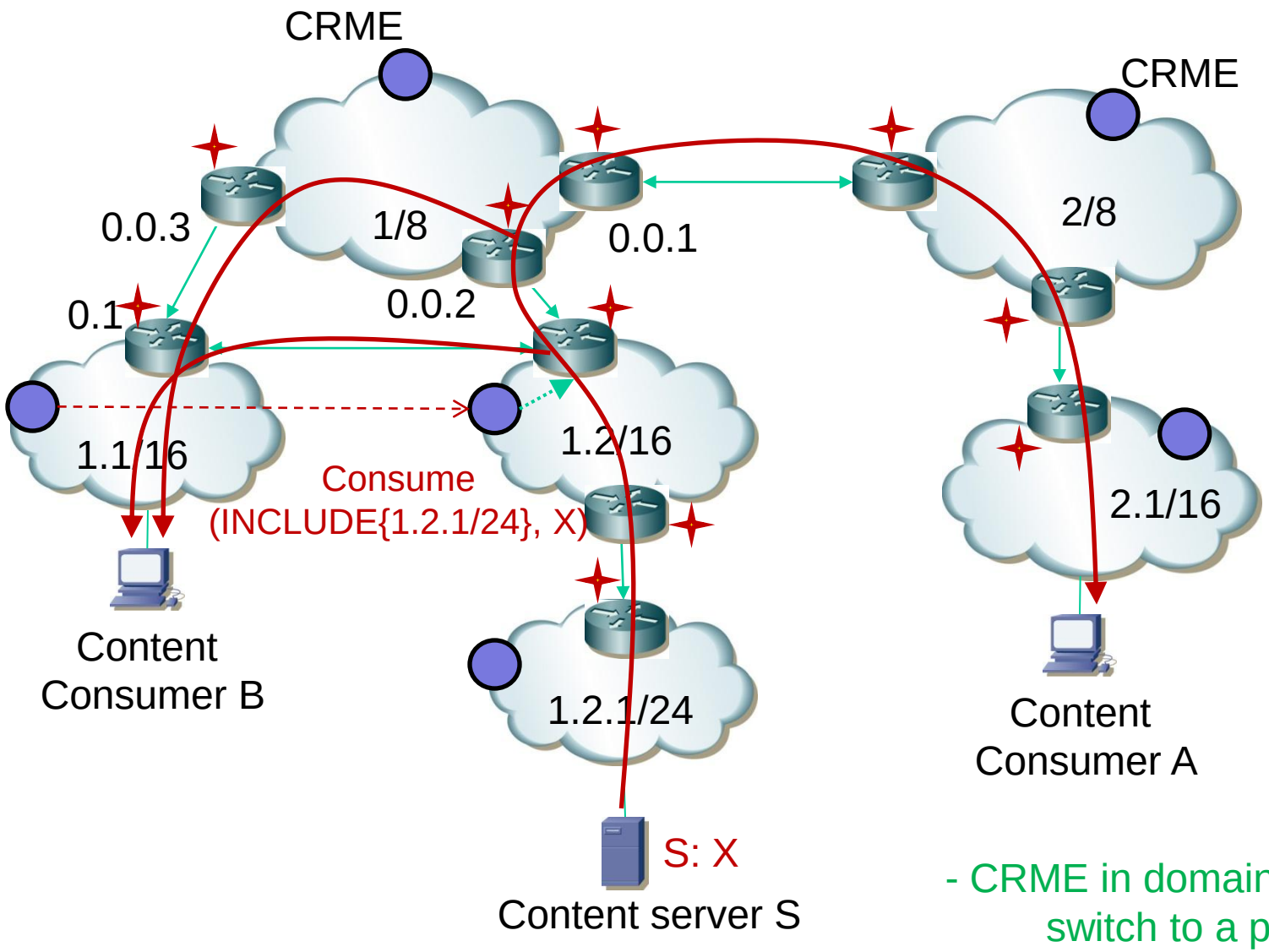
An Example



CRME in domain 1/8 update
for context ID X:
Ingress CAFE = 1.0.0.2
Egress CAFE = {1.0.0.1, 1.0.0.3}

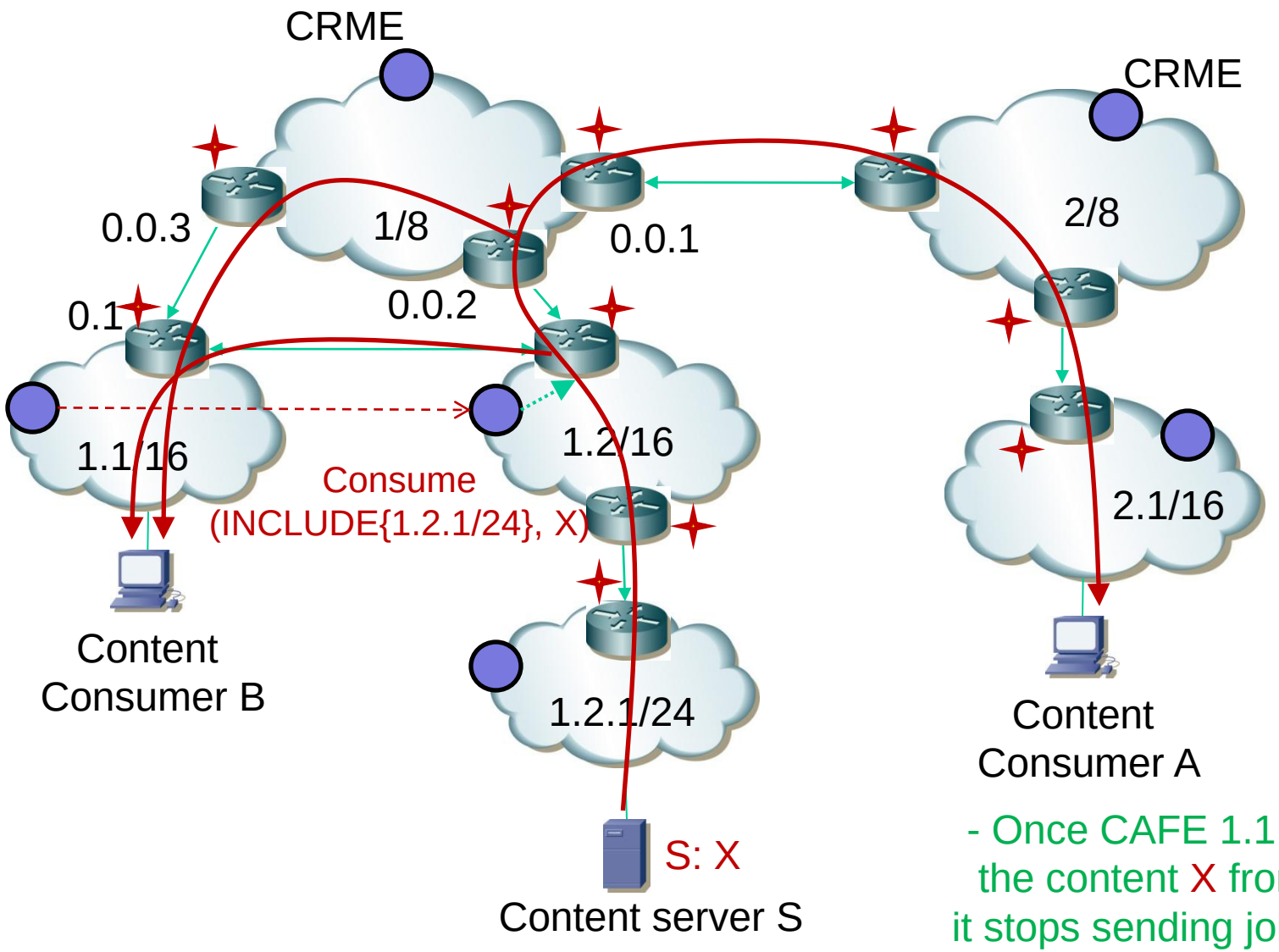
- Content consumer B starts to request the content X with wildcard

An Example



- CRME in domain 1.1/16 starts to switch to a peering route

An Example



- Once CAFE 1.1.0.1 has received the content X from the peer route it stops sending join requests on the provider route

Summary for the Coupled Approach

- The coupled approach follows hop-by-hop paradigm for content resolution and consumption.
  - Content resolution paths at the domain level is used for content delivery
  - Offers graceful support of **inter-domain multicast**
  - Offers **bi-directional location-independence**
    - Explicit source and receiver locations are never exposed to each other
    - Strengthening security aspect of the infrastructure
  - Offers **locational preference indication** via scoping and filtering functions

COntent Mediator architecture for content-aware nETworks

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