



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

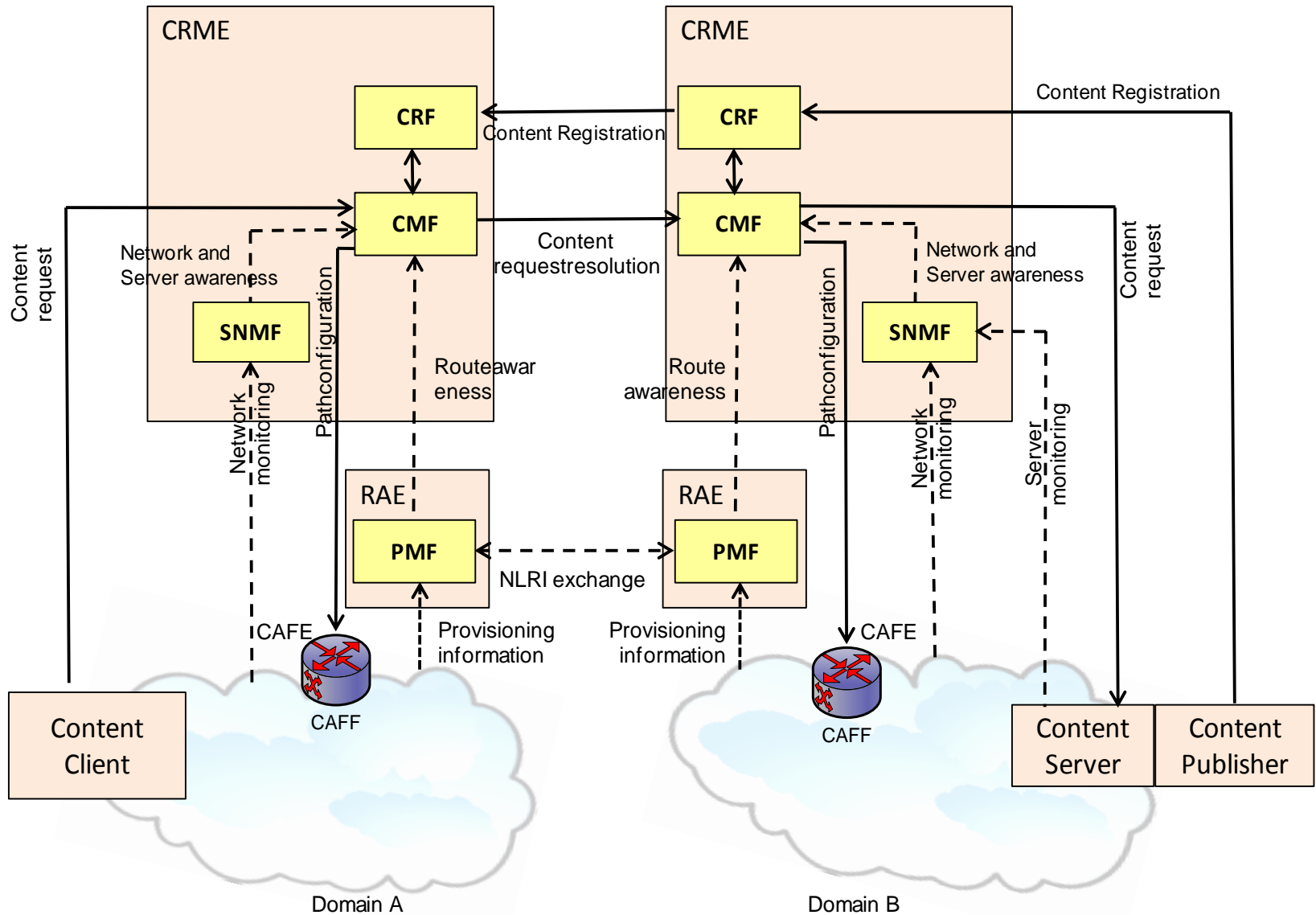
Wei Koong Chai, *Ioannis Psaras*, George Pavlou
UNIVERSITY COLLEGE LONDON (UCL)



Ning Wang
UNIVERSITY OF SURREY (UniS)

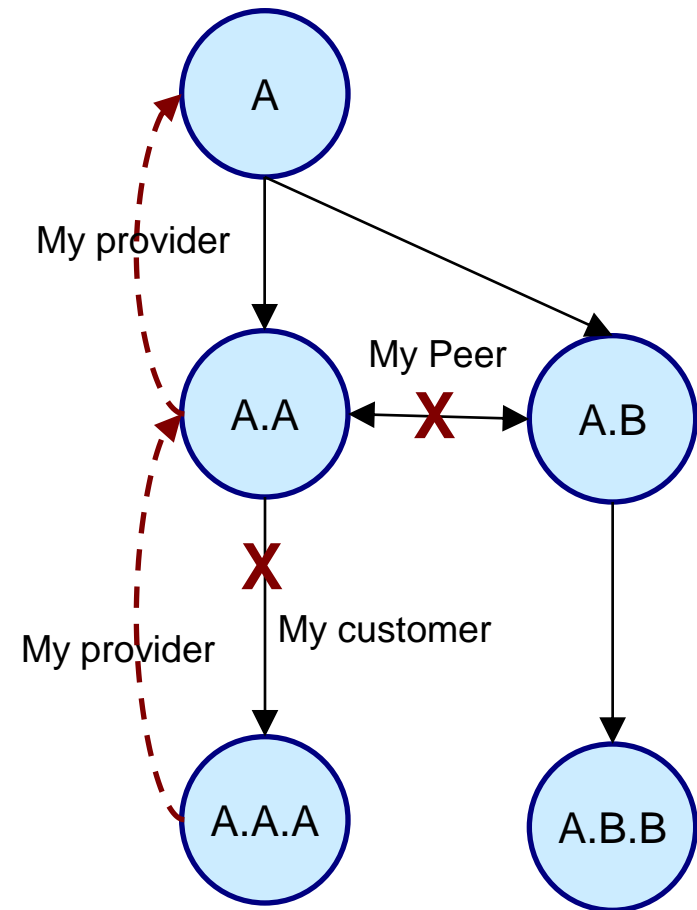


- CURLING: An infrastructure to both accurately and efficiently **hit** (or **not hit**) content objects in specific regions / areas *of the Internet*.
 - The content resolution is natively **coupled** with path setup.
 - Follows a domain-level **hop-by-hop gossip-like communication model** without revealing 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



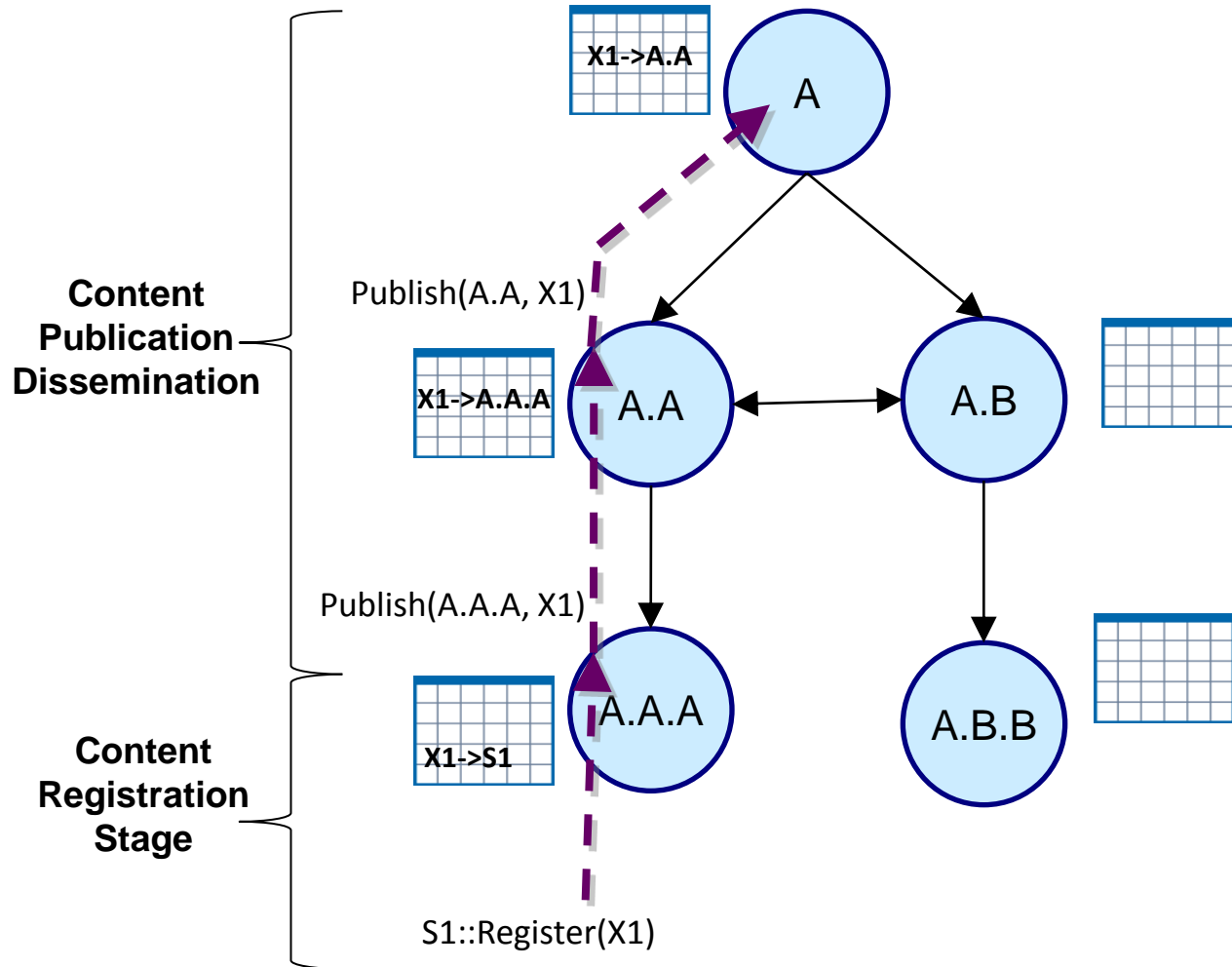
- Main entities:
 - **Content Resolution and Mediation Entity (CRME)**
 - Resides in individual ISP
 - Collaboratively handles content publication requests, discovers requested content and supports content delivery
 - **Content-aware Forwarding Entity (CAFE)**
 - Typically edge routers
 - Collaborates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

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



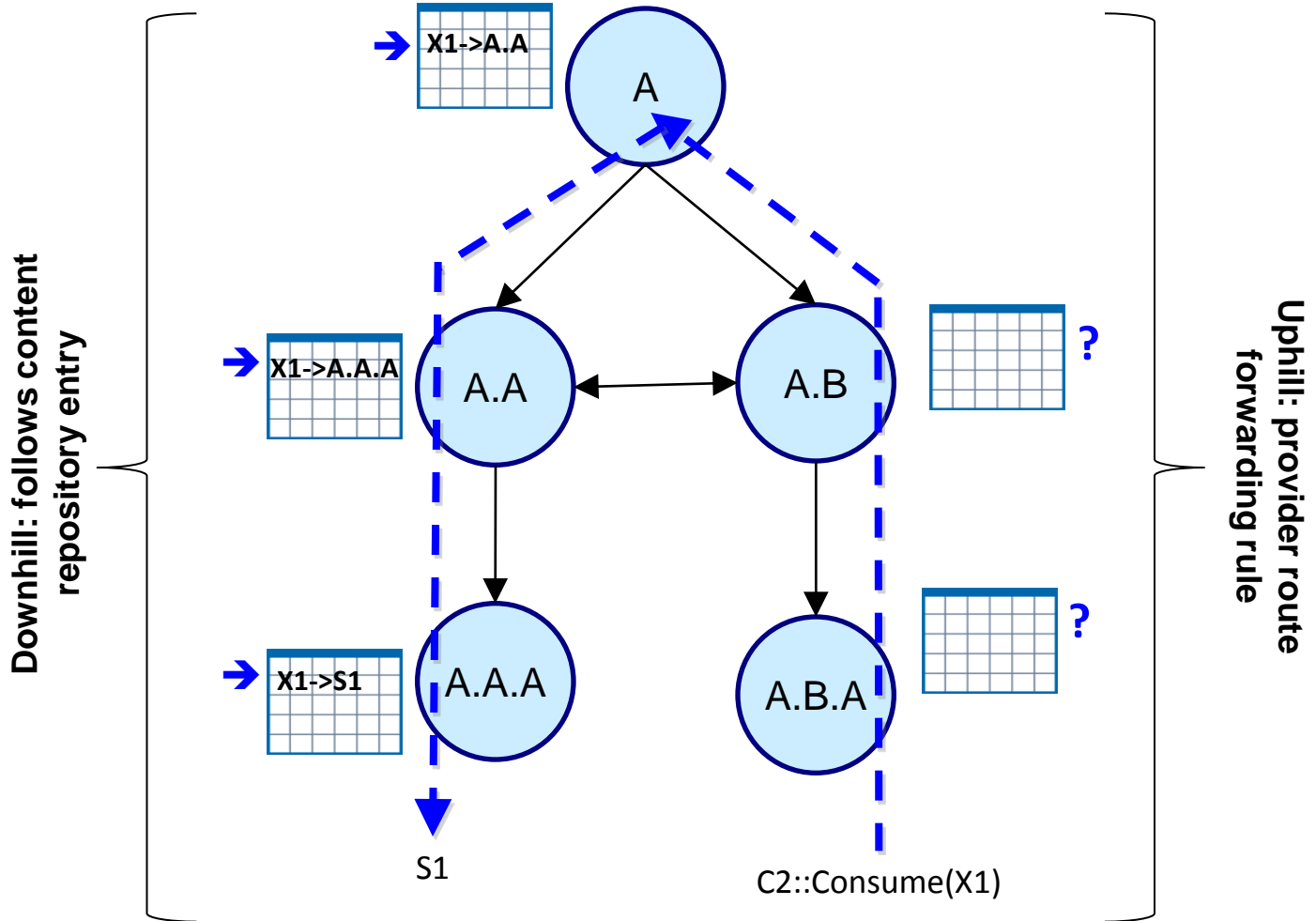
- Content publication – the process of making content available in the Internet
- **Stage 1:** Content registration
 - Content provider registers a new content (or a replica) to the local CRME
 - CP sends a `Register` message to the local CRME
 - with explicit location of the content (e.g., IP address 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”



- 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 – 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



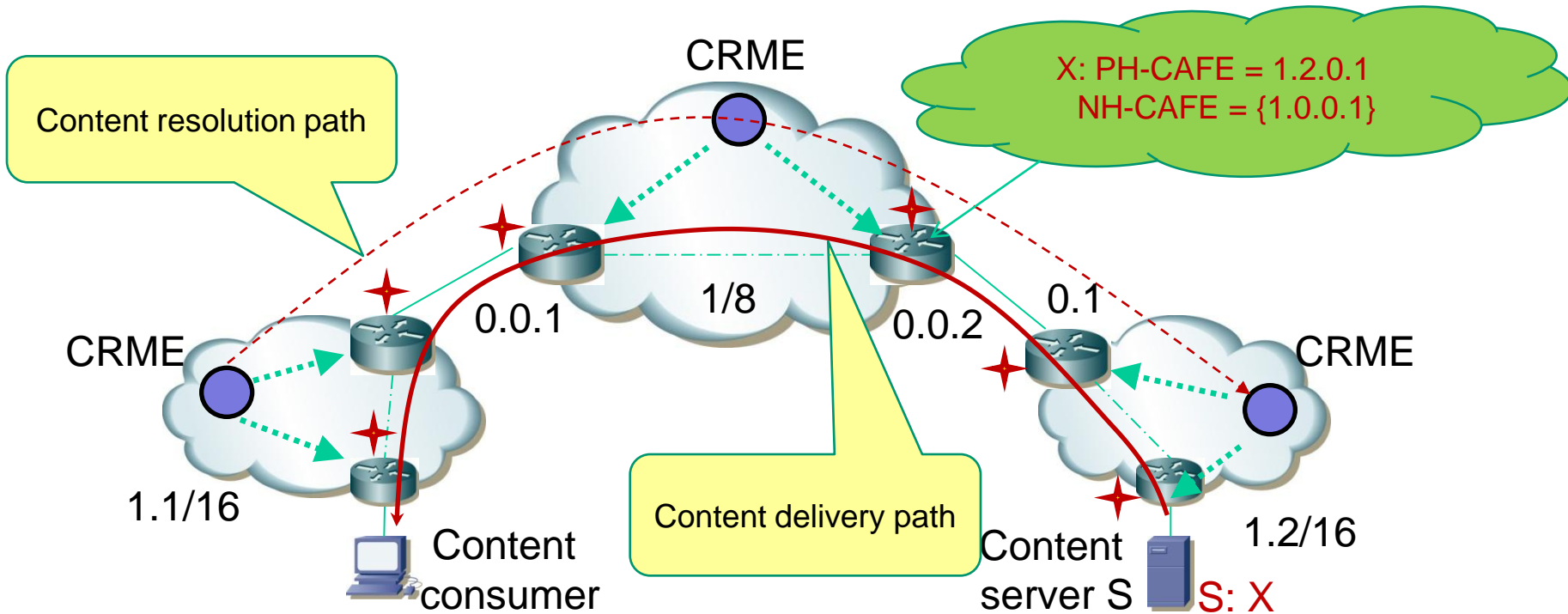
- Resolution modes:
 - Scoped mode
 - specific source(s) only
 - forwarding of request follows **BGP routes**
 - Wildcard mode
 - any source(s) in the Internet
 - forwarding of request follows business relationships between domains (**the provider route forwarding rule**)
 - Filtered mode
 - NOT from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

- 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

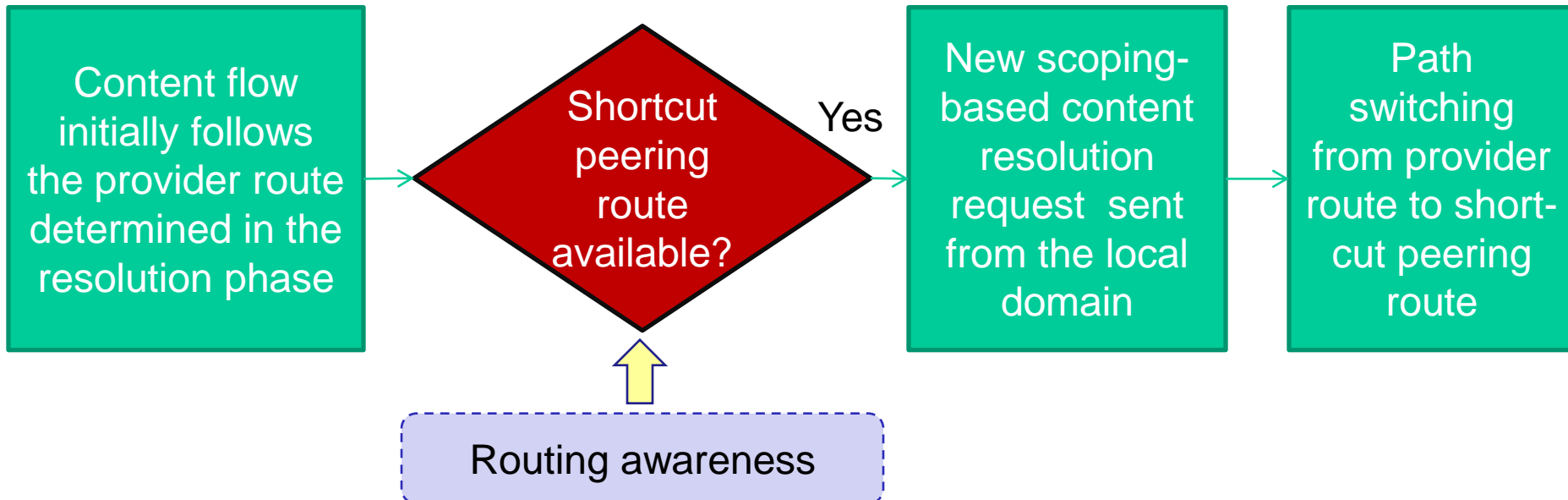


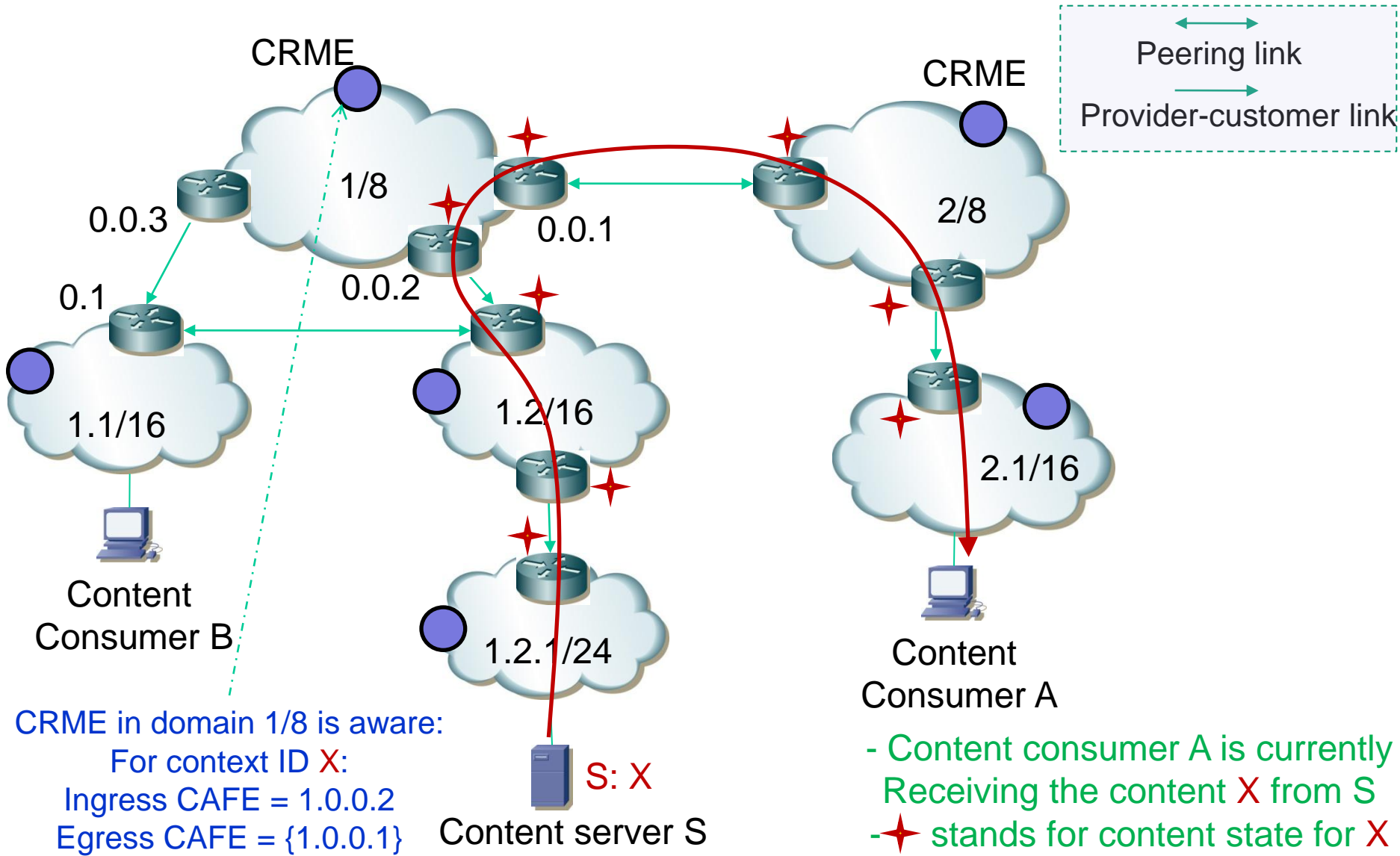
• CRME Functions

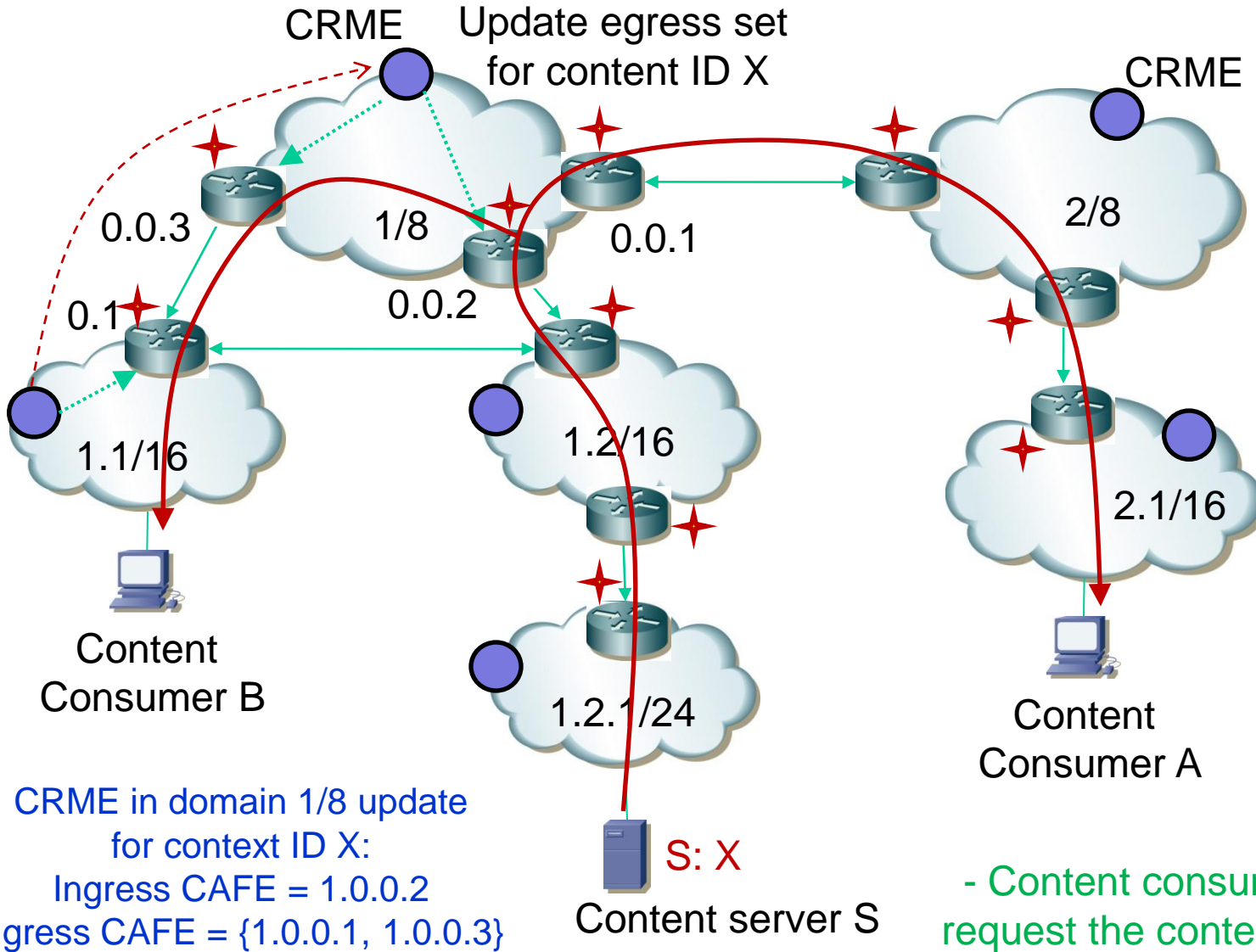
- Forwarding content resolution requests across domains
- Configuring content states at local ingress and egress CAFEs
- NOT responsible for carrying content flows (physically decoupled from CAFE)

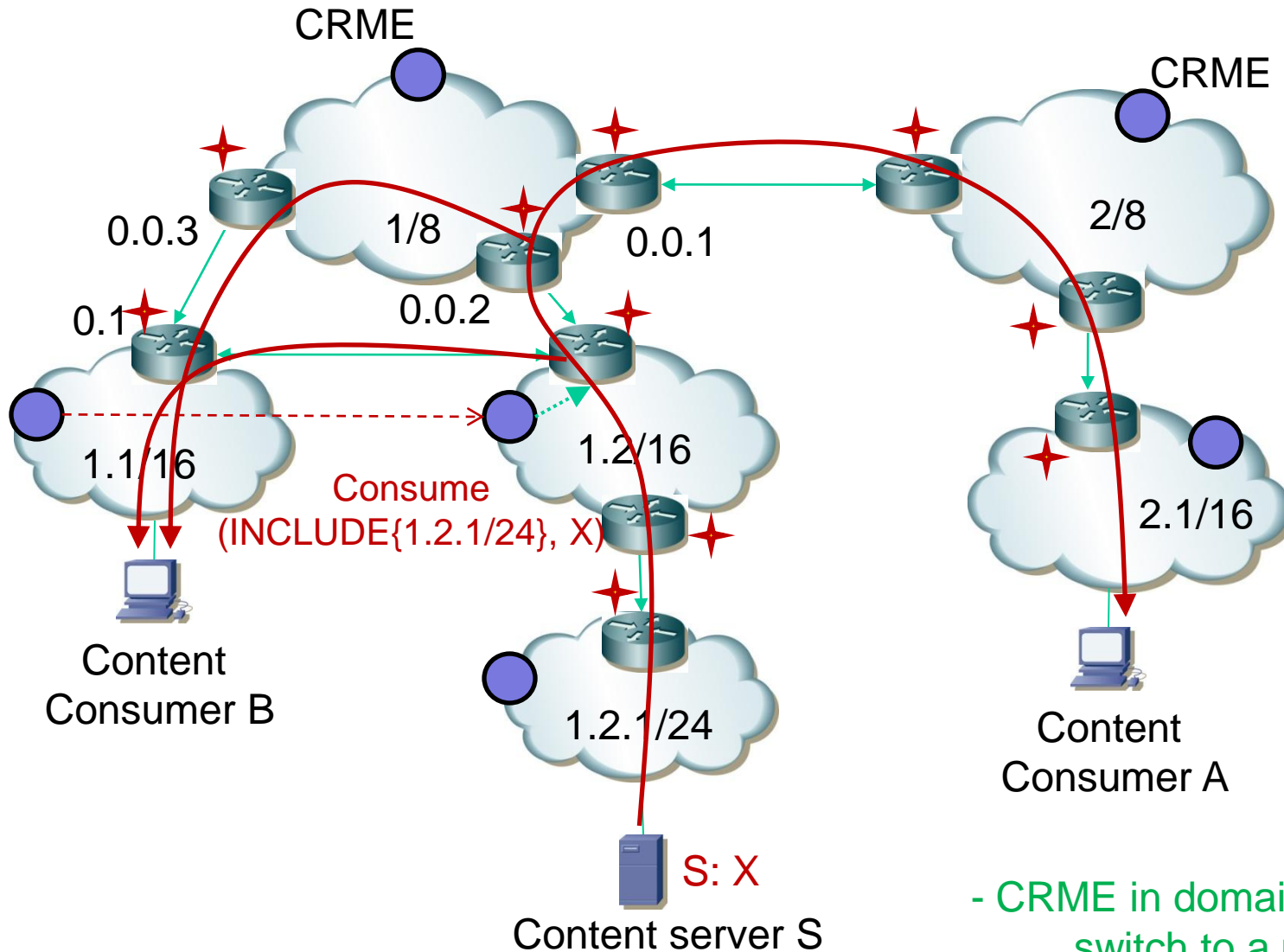
- **Where** – Content states are only maintained at CAFEs that are normally planted at the network edge as ingress/egress nodes
- Core IP routers within the network are not content-aware and hence do not recognise the content identifier
- **Content forwarding rules at CAFEs (supporting inter-domain multicast)**
 - 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

- 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

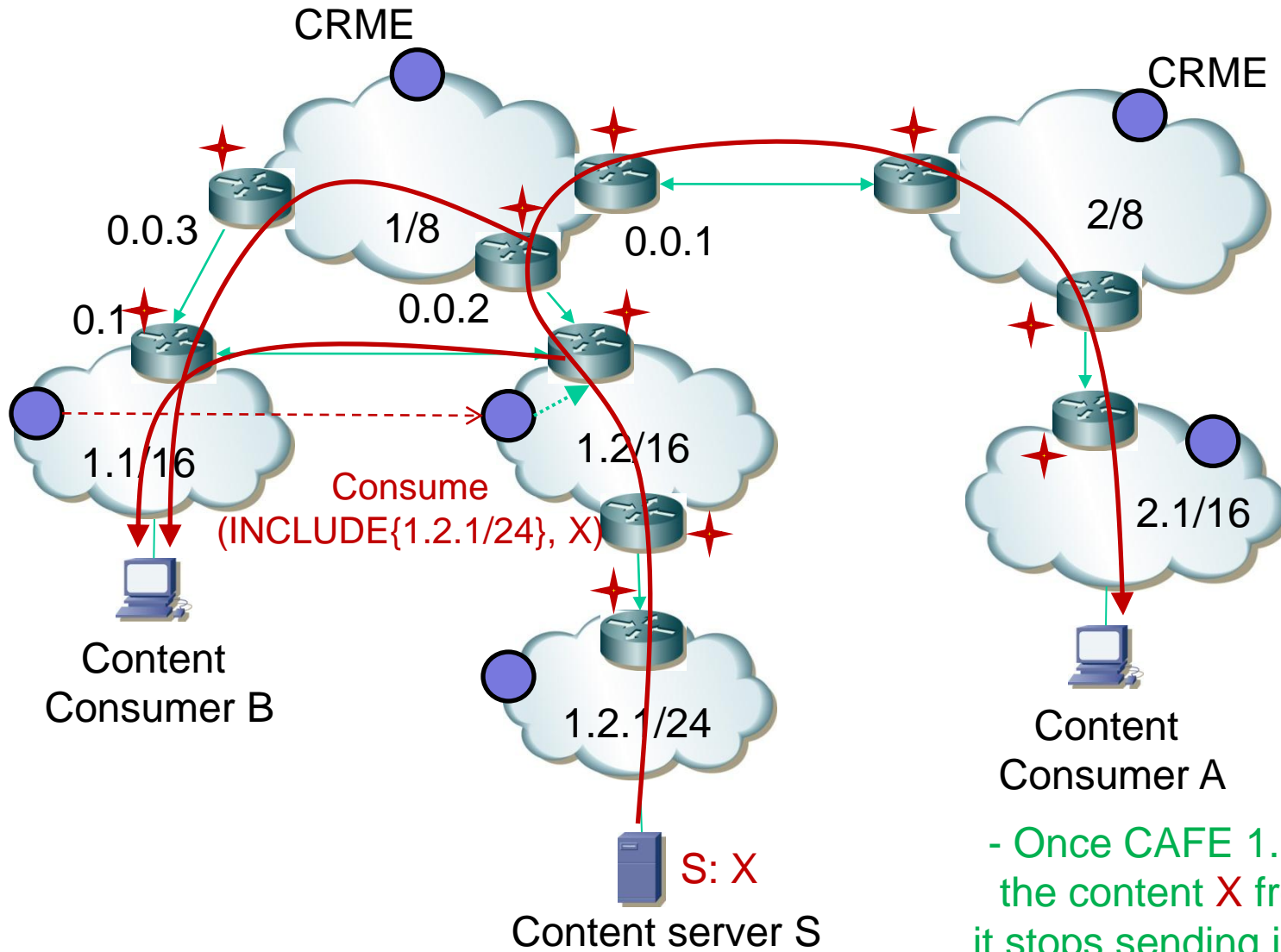








- CRME in domain 1.1/16 starts to switch to a peering route



Consume
(INCLUDE{1.2.1/24}, X)

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

- 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

