RIOT, Internet of Things and ICN

RIOT Summit, July 2016

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IoT, ICN, RIOT

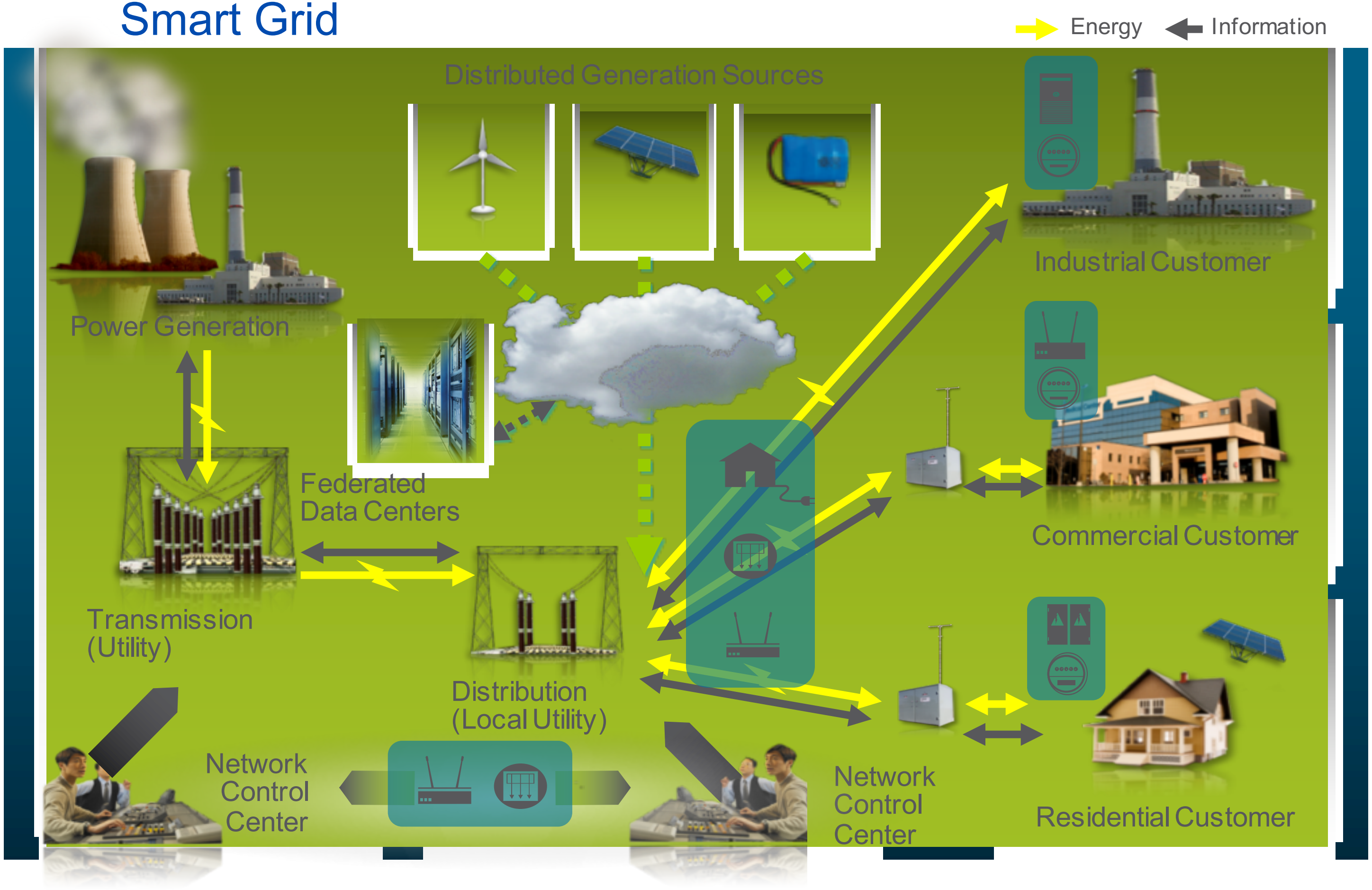
- *Internet of Things*
- *Information Centric Networking*
- *RIOT*

Internet of Things

- Connect sensors, actuators, devices, systems with analytics, management and control
- Interconnect systems that formerly operated independently
- Use open, standards-based protocols and infrastructure to maximize opportunities for innovation

Power Management

Smart Grid



“Things” at the edge

- Sensors, actuators, other devices
- These devices often have quite limited resources
  - Energy
  - Memory
  - CPU
  - Network
- Challenge: Provide quality connectivity with these limited resources

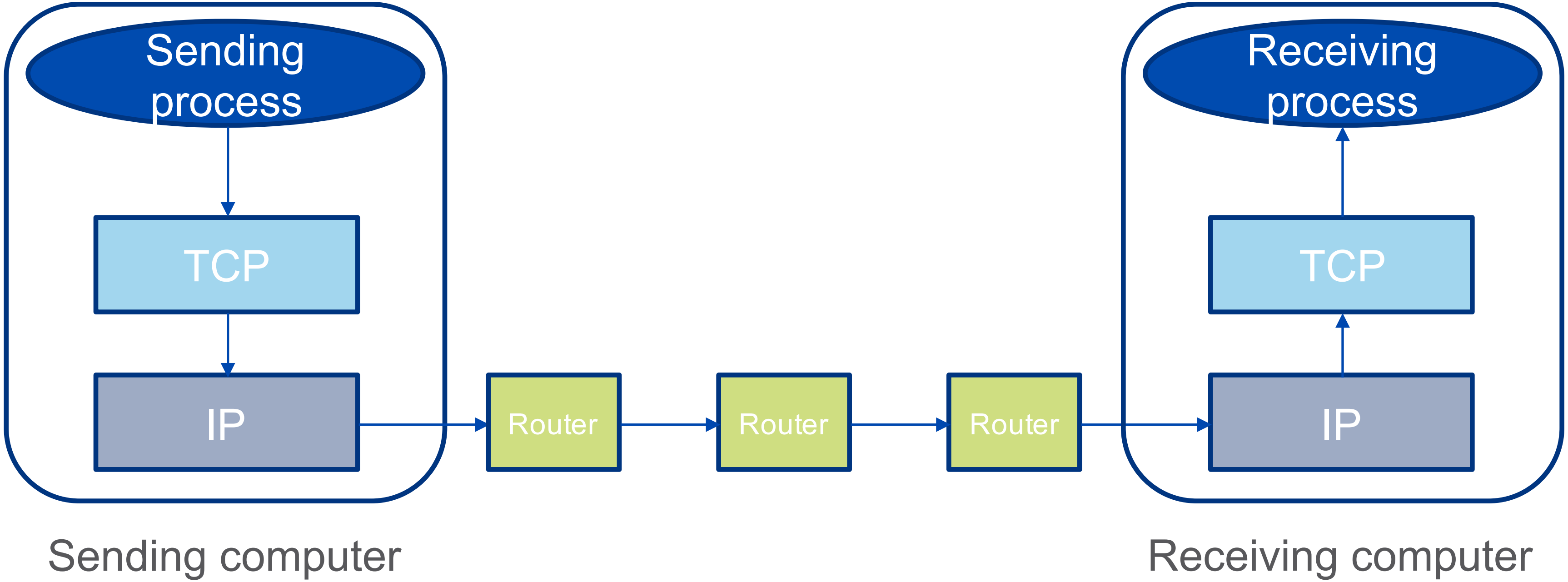
Communication Protocols and the Internet

- *Communication protocols* define how devices interact over a telecommunication network
- From the Greek *protokollon,* a description of the contents of a manuscript
- These protocols are based on a series of design principles, guidelines and decisions that shape the way devices communicate and across the Internet
- Information Centric Networking (ICN) is a radical rethinking of the network communications paradigm, based on many different design guidelines and decisions

TCP/IP Protocol Suite

- Communication is between processes/hosts,identified by addresses
- End-to-end principle – network forwards with no state per message
- Reliable delivery
- Congestion control
- Address is fixed-length number combining identification and location
- Multicast – best effort with several styles of implementation
- Mobility – change in location implies change in address

Sending Data with TCP/IP



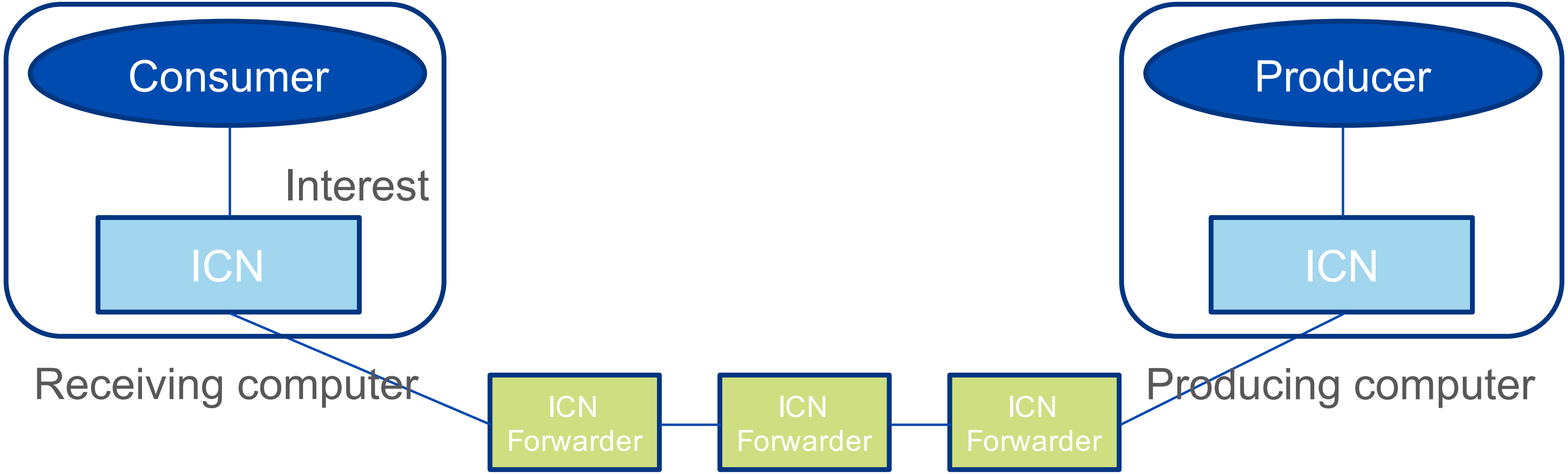
Information Centric Networking: ICN

- Networking technology that starts from a clean slate; shares “packet forwarding” with IP and not much else
- Based on the observation that Internet traffic today is largely requesting data; think of requesting web pages
  - Consumer generates a request for some *named data*, called an *Interest*
  - Interest is forwarded to a place (or places) in the network where the corresponding named data exists; each forwarder records the interface on which the Interest was received
  - Data is returned in a *Content* message. Following back pointers
- Data in Content is crypto-signed to prove validity
- Contents can be pre-stored at multiple locations in the network
- Contents can be cached by forwarders for later use

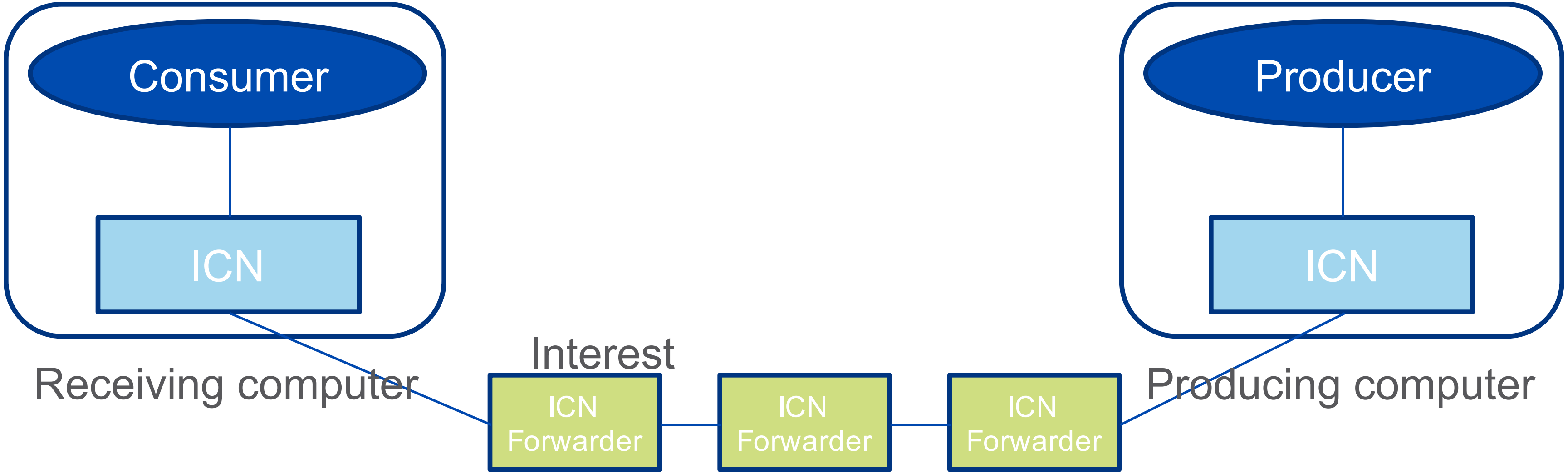
Characteristics of ICN

- Communication is between consumers and named data
- Forwarders interact with messages and maintain per-message state
- Names for data (no addresses for devices)
- Novel forwarding strategies
- Ad-hoc multicast through content storage in forwarders
- Consumer mobility is easy
- Open questions…
  - Push model communication in a pull model world
  - Routing
  - Congestion control
  - ...*and many more*

ICN Example


Consumer
Interest
ICN
Receiving computer
ICN Forwarder
ICN Forwarder
ICN Forwarder
Producer
ICN
Producing computer

ICN Example



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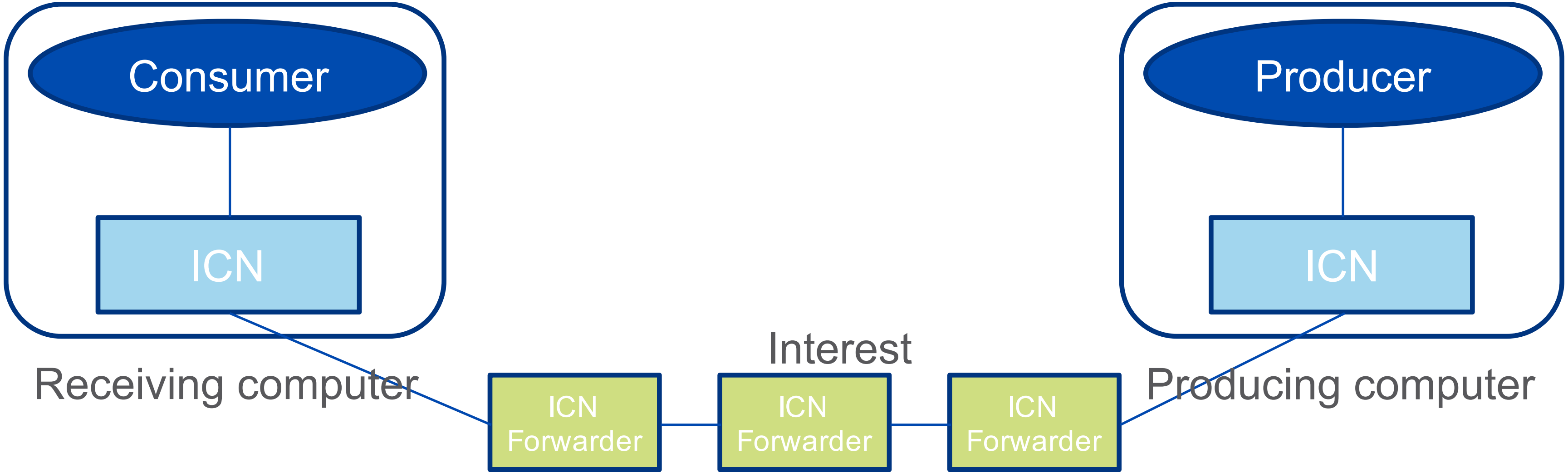
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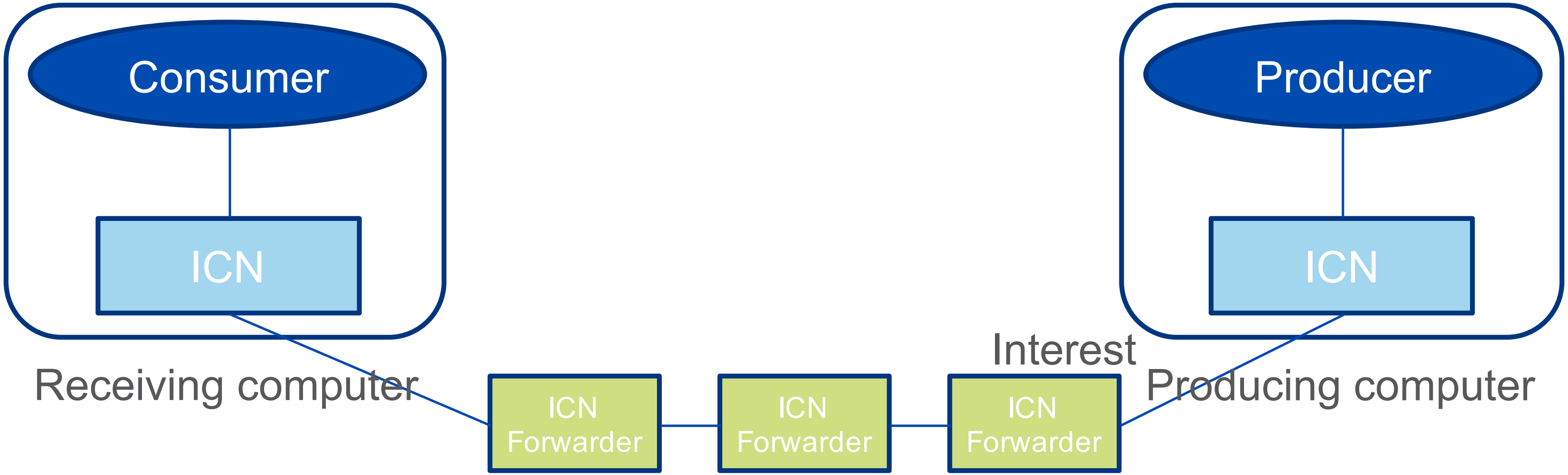
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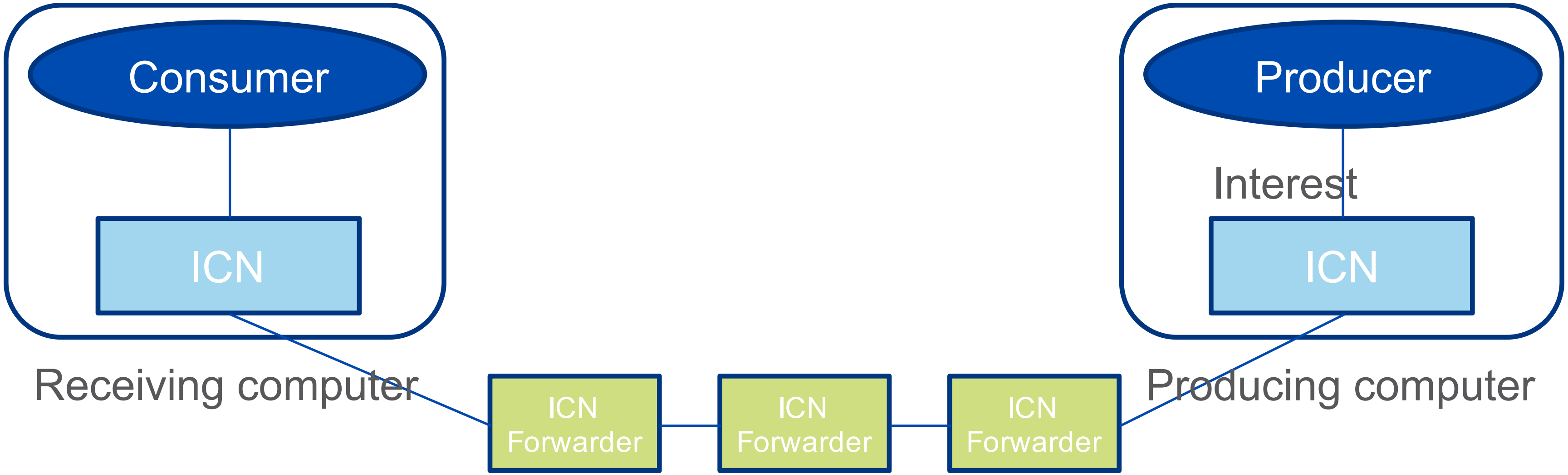
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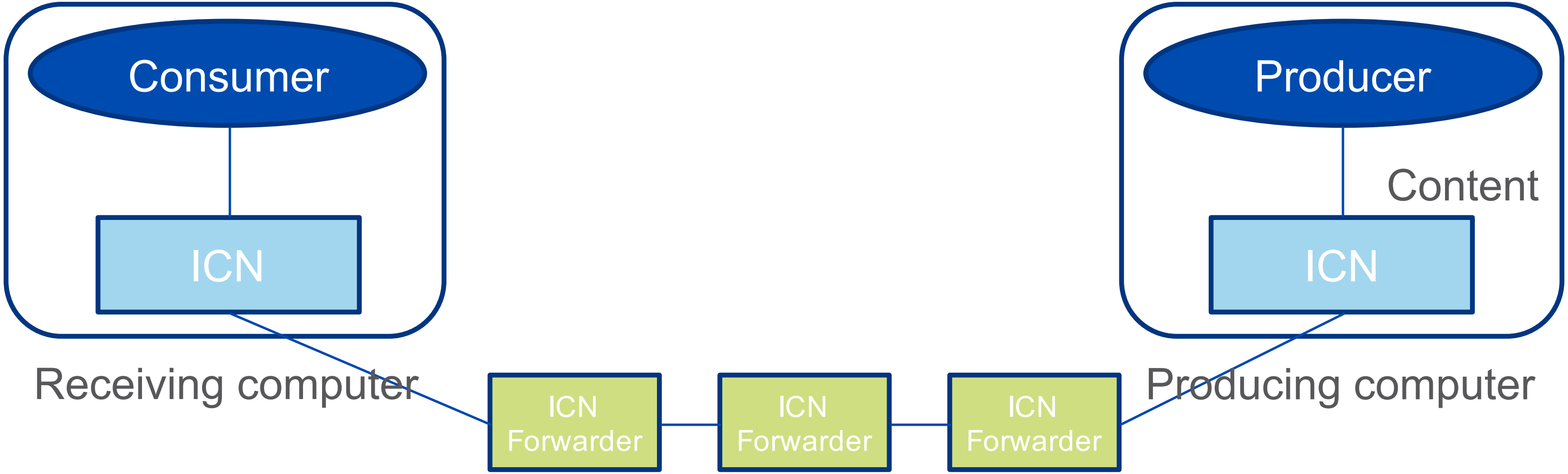
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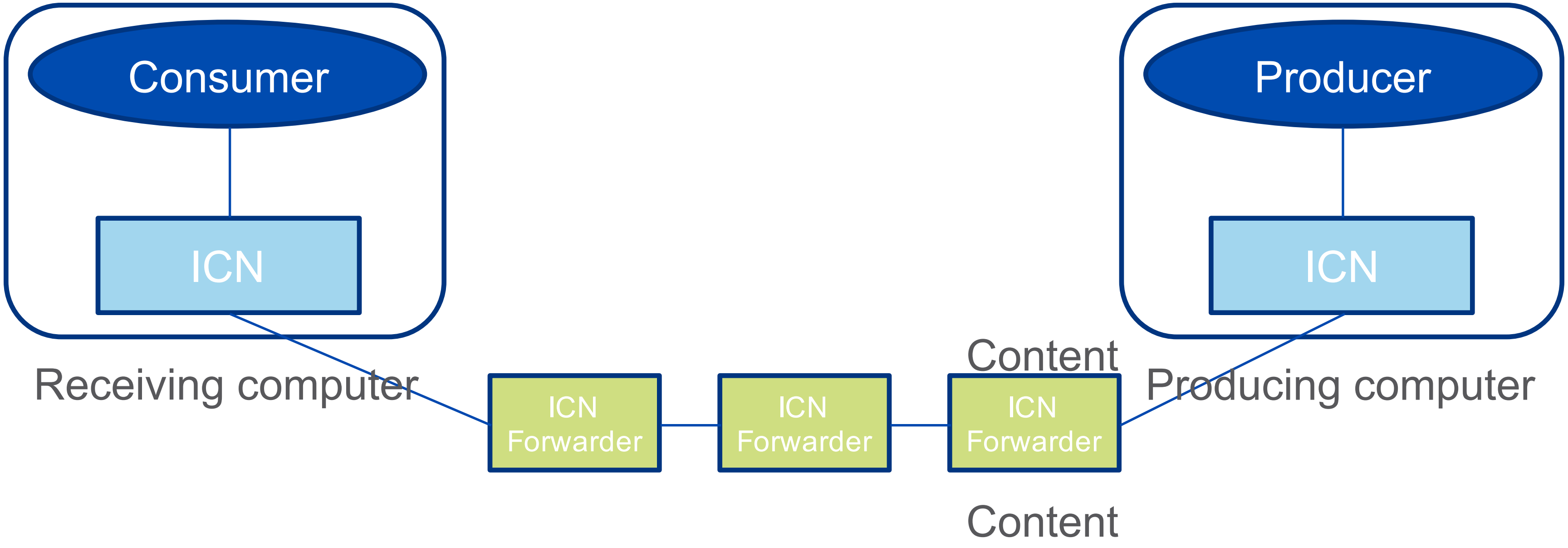
ICN Example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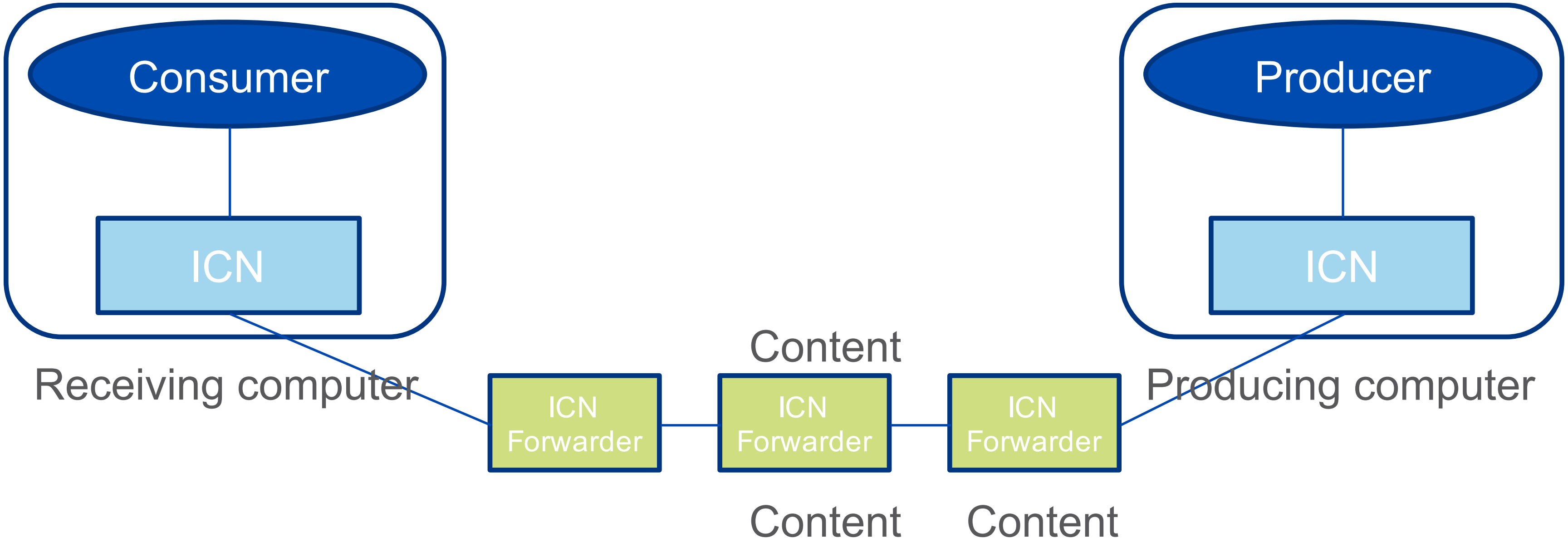
ICN Example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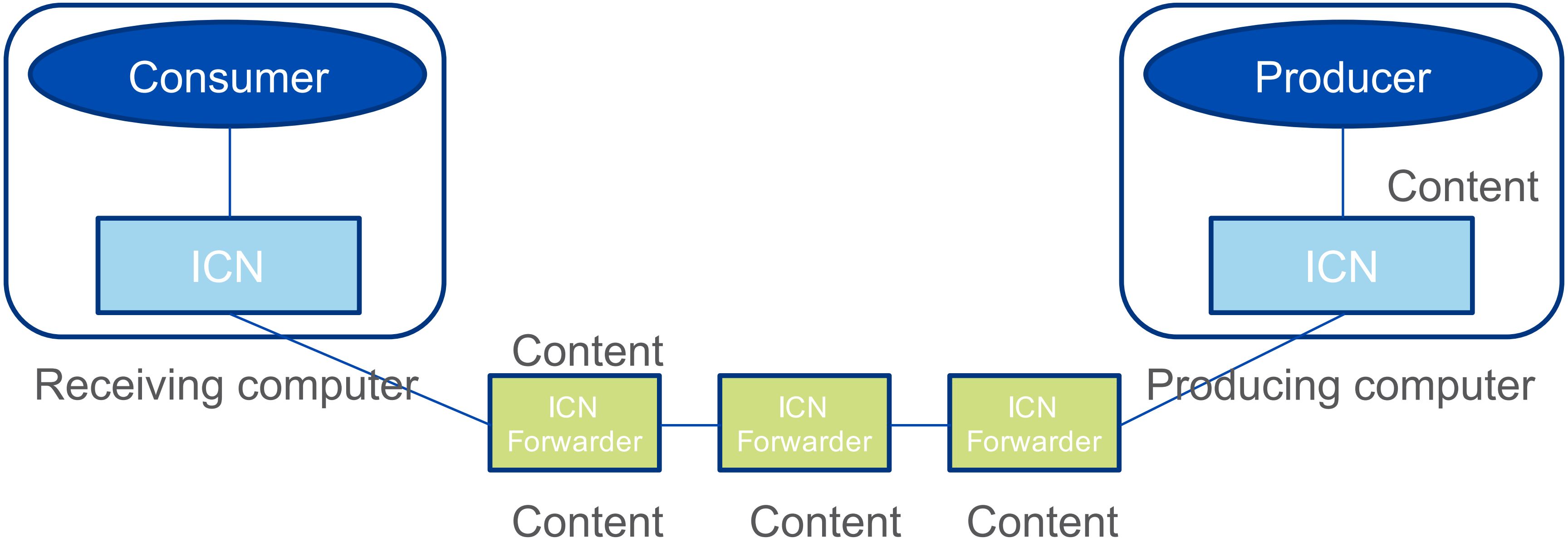
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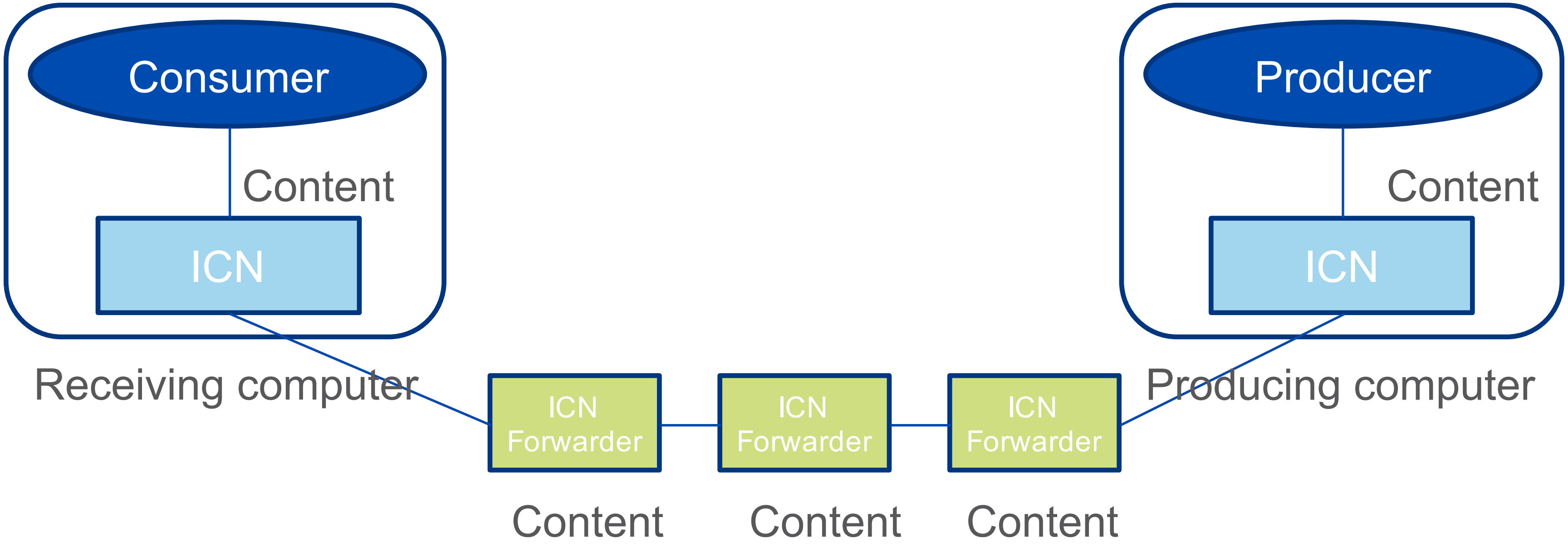
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Producing computer
ICN Forwarder
ICN Forwarder
ICN Forwarder
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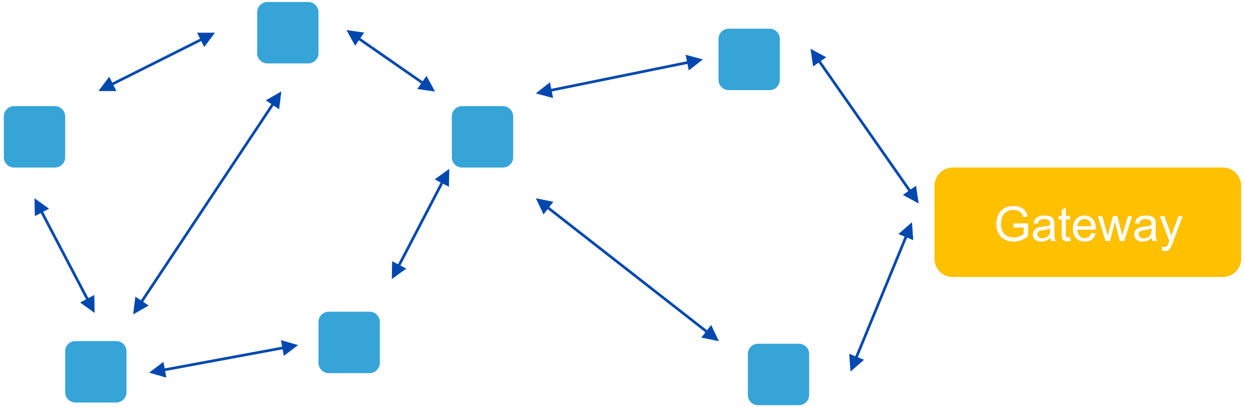
Content
Content

Why ICN for Constrained Networks?

- Simplicity – implementation, operation
  - Mobility/dynamic topology
  - Novel forwarding strategies
  - Address management
  - Routing
  - Security

Node-Gateway Data



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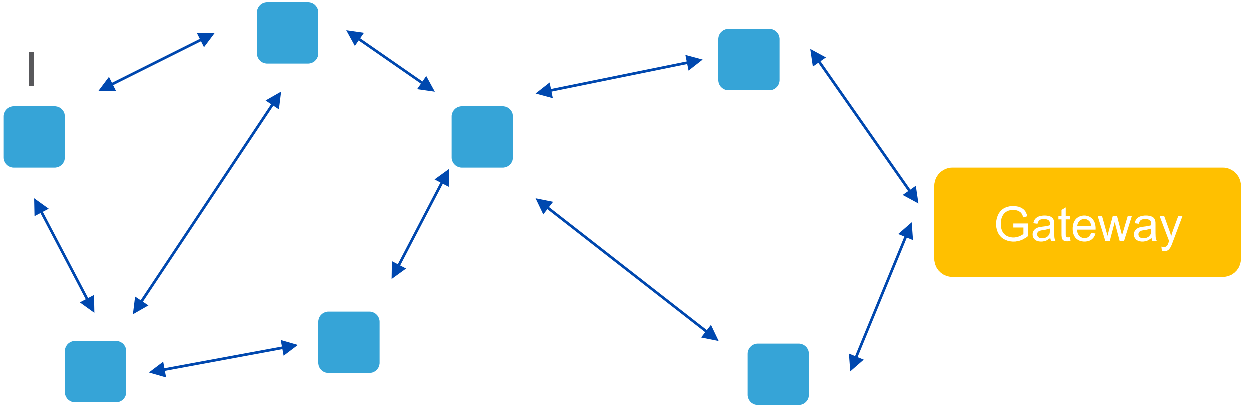

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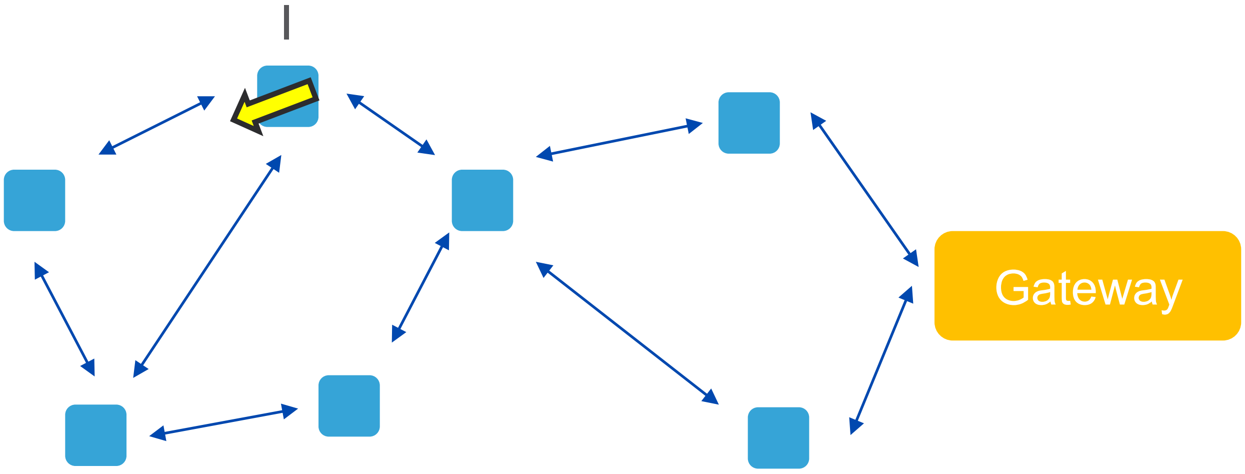

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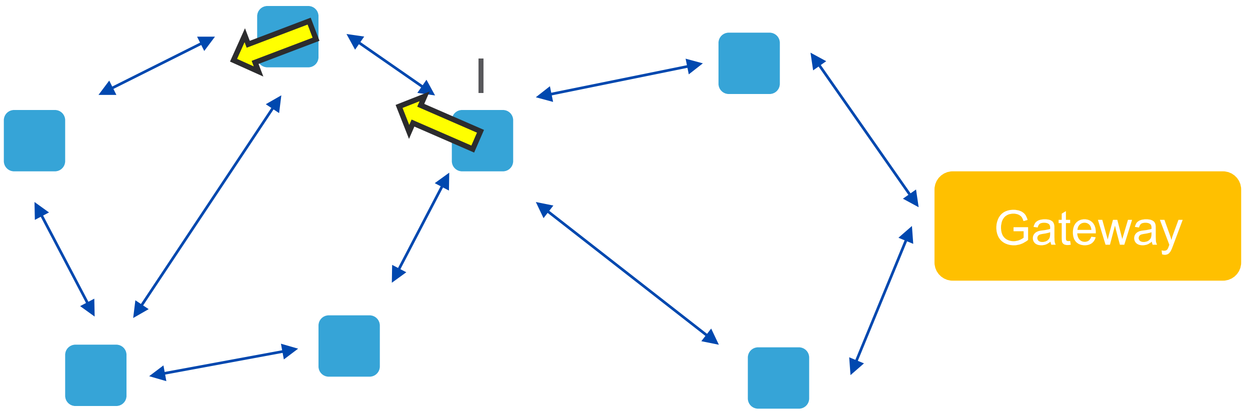

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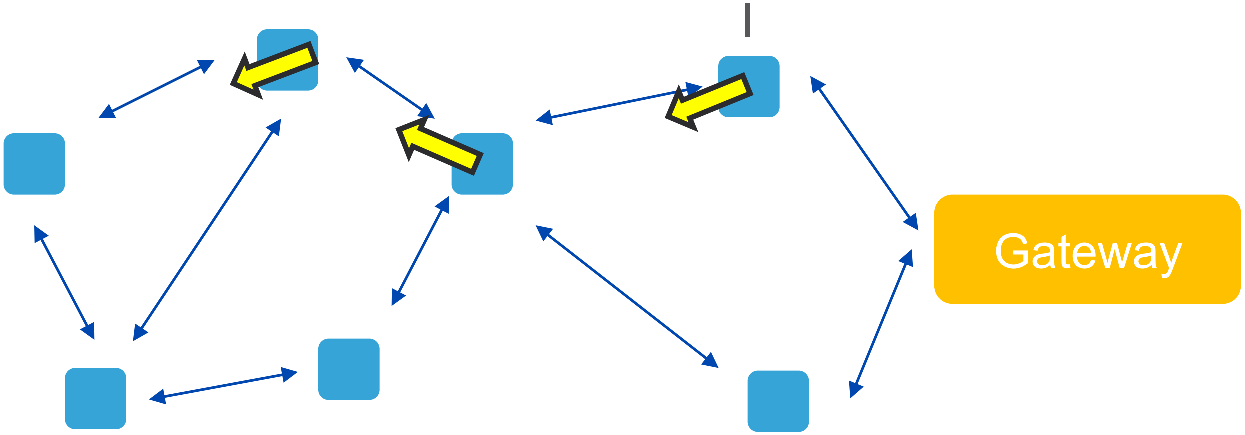

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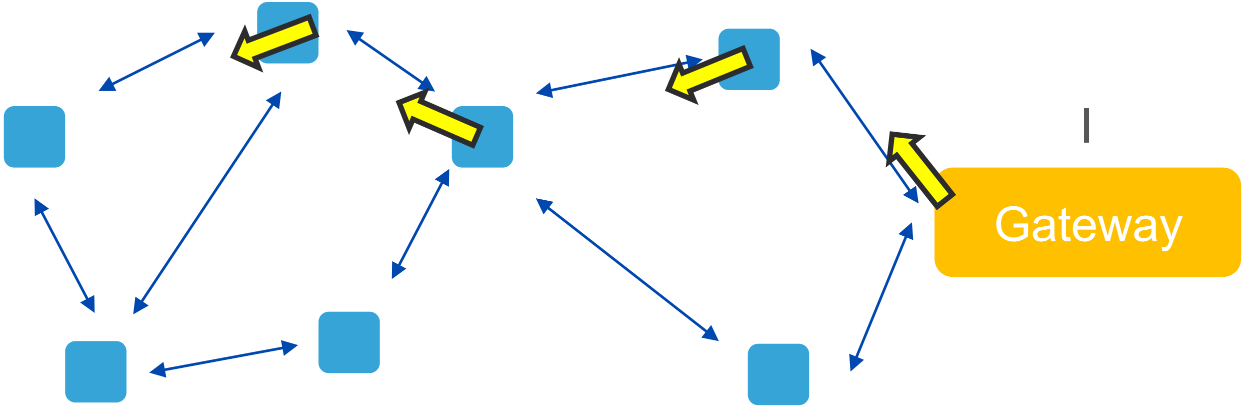

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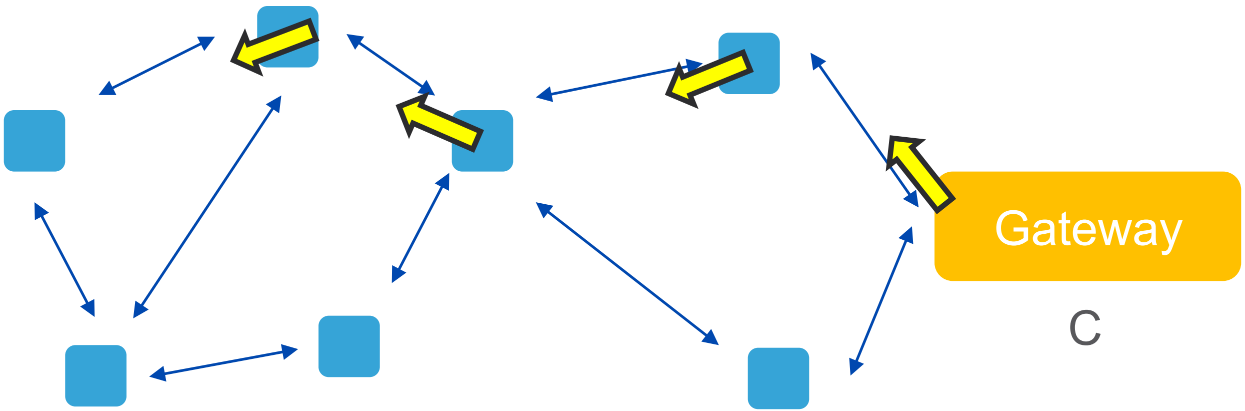

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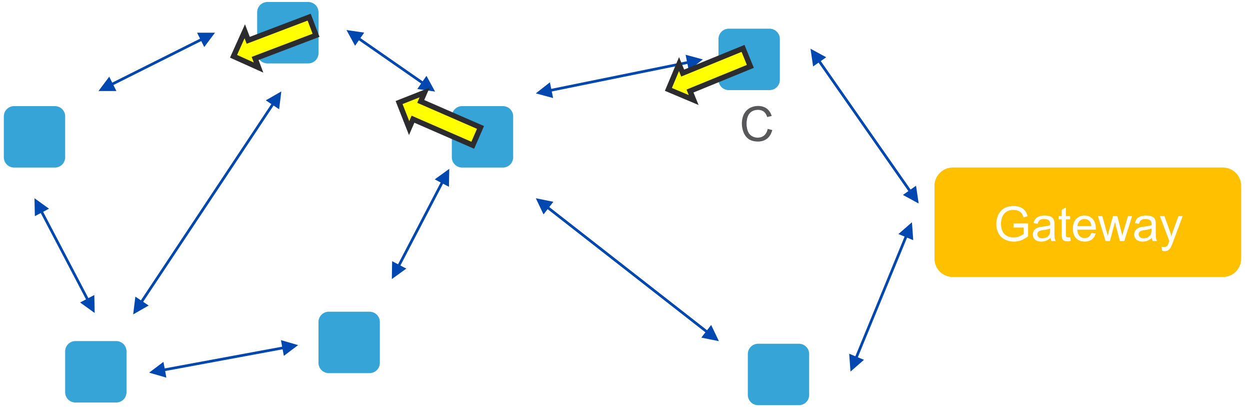

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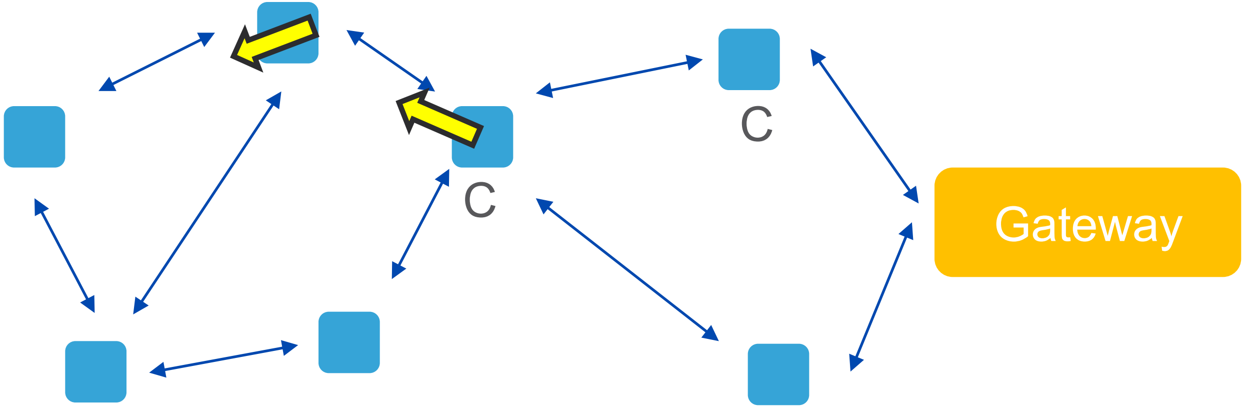

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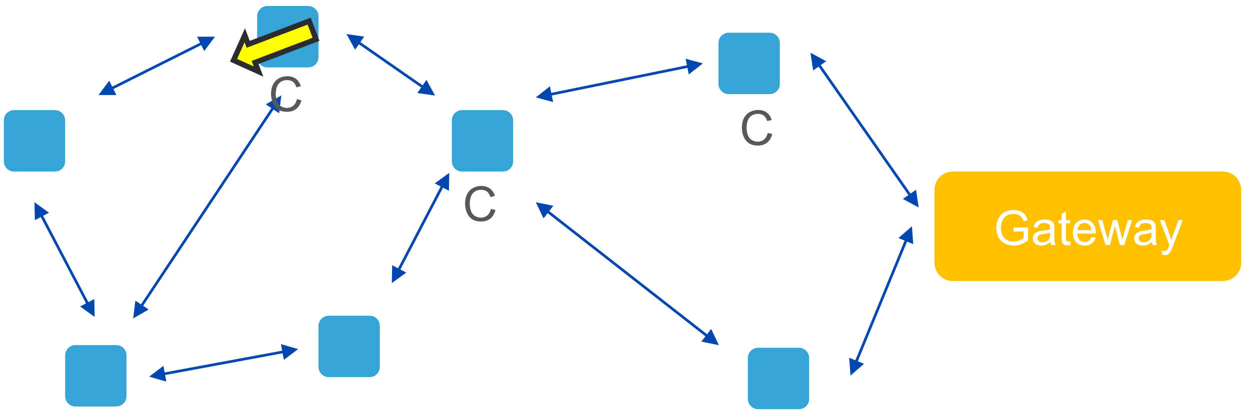

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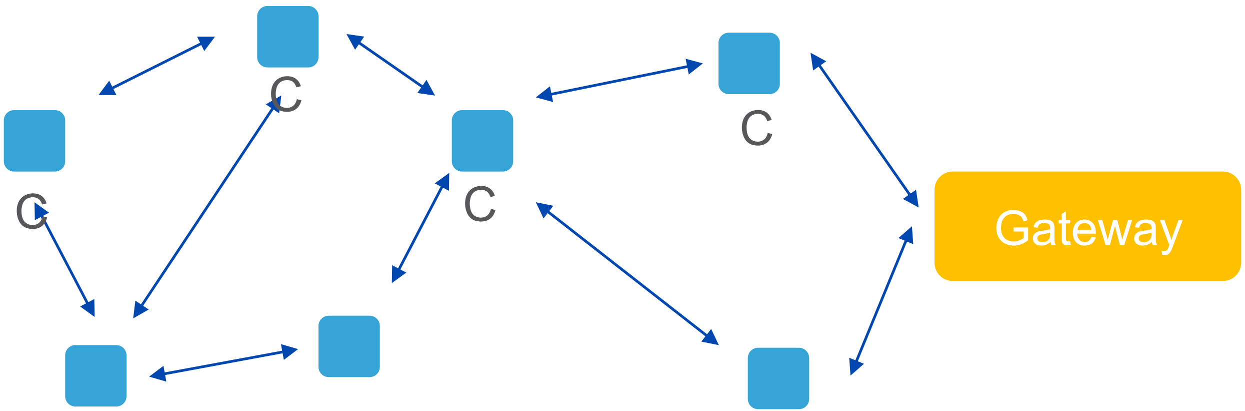
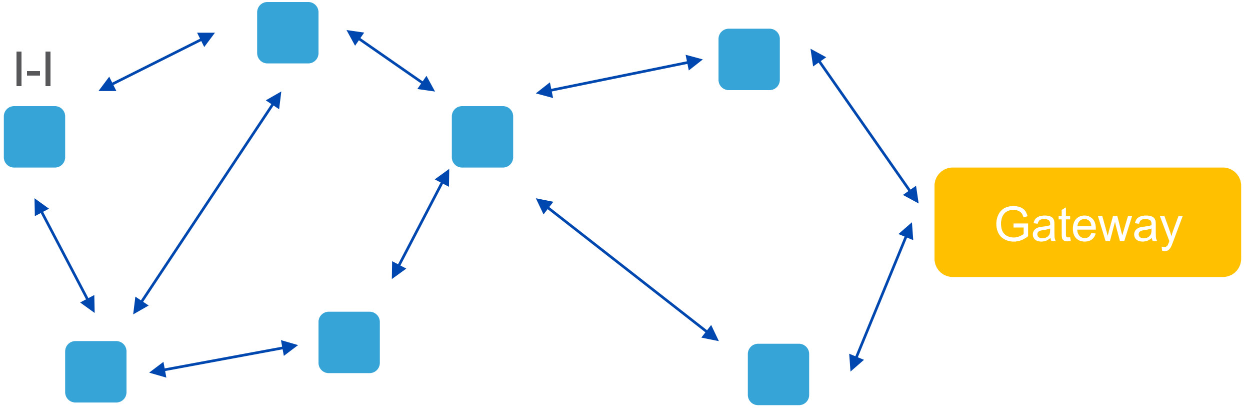


Gateway-Node Communication *(Asynchronous)*



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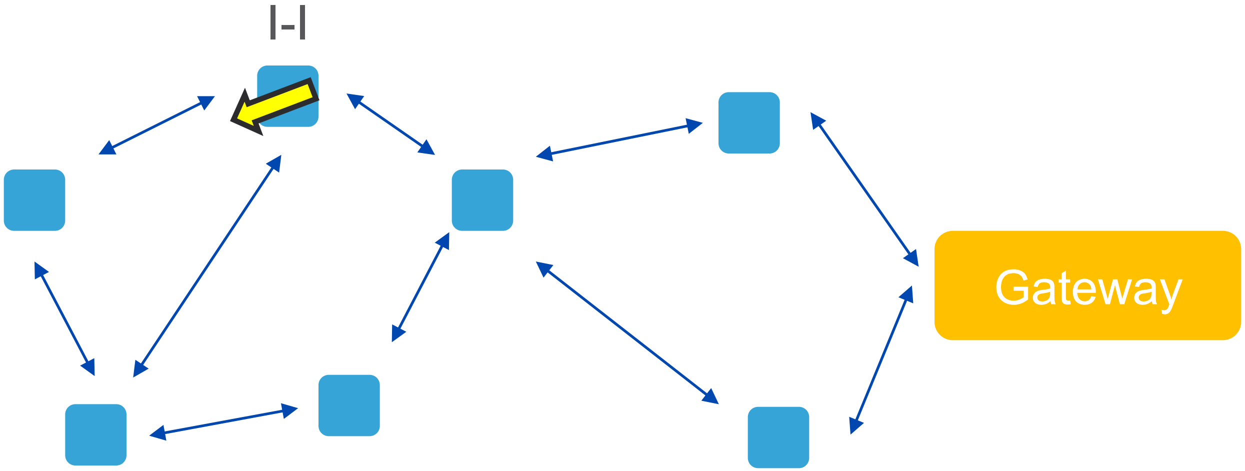

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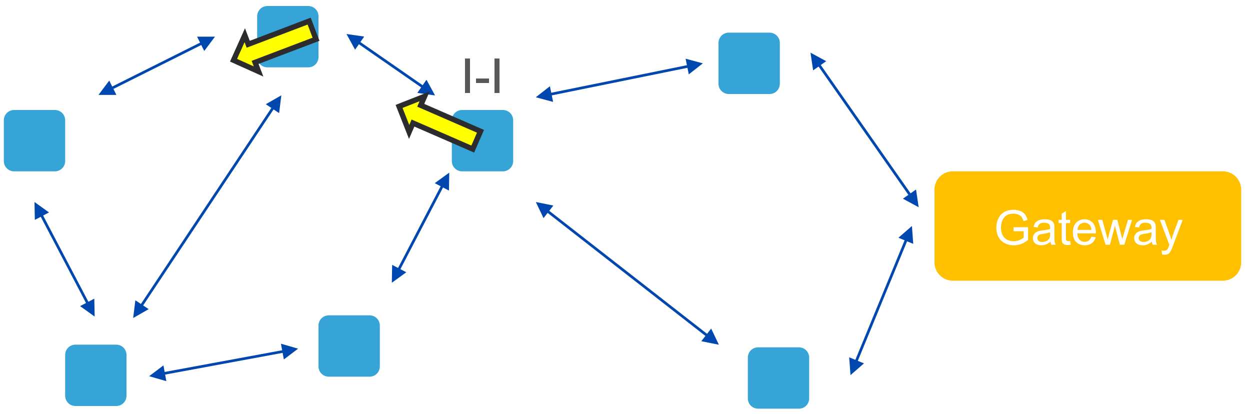

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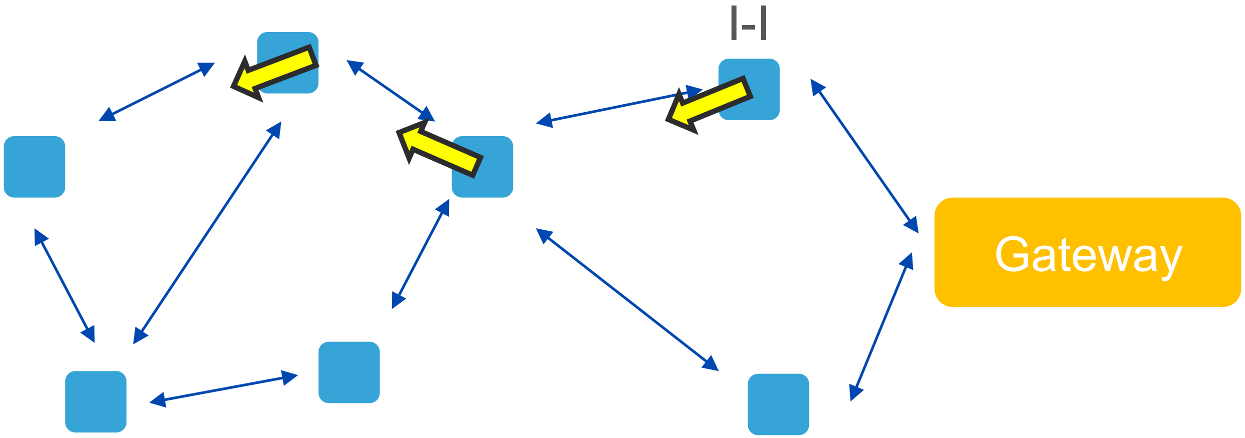

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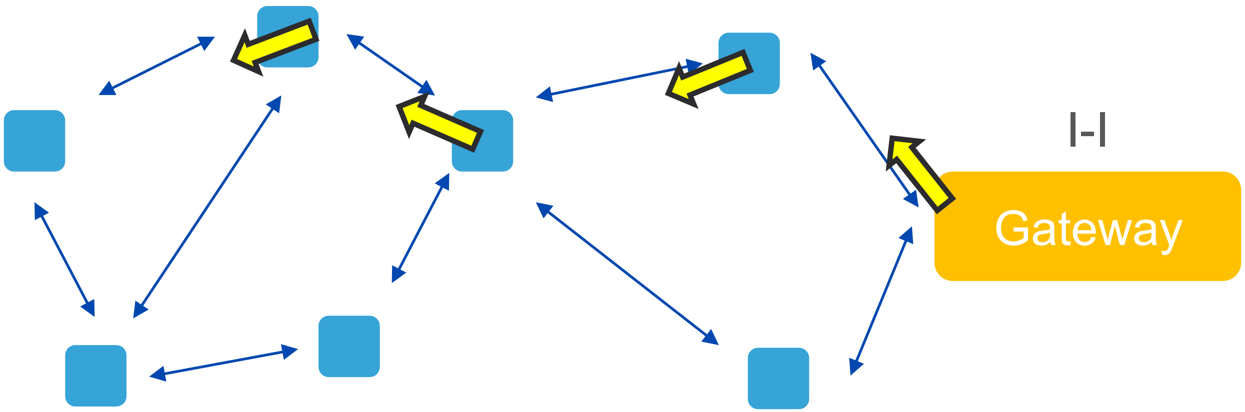

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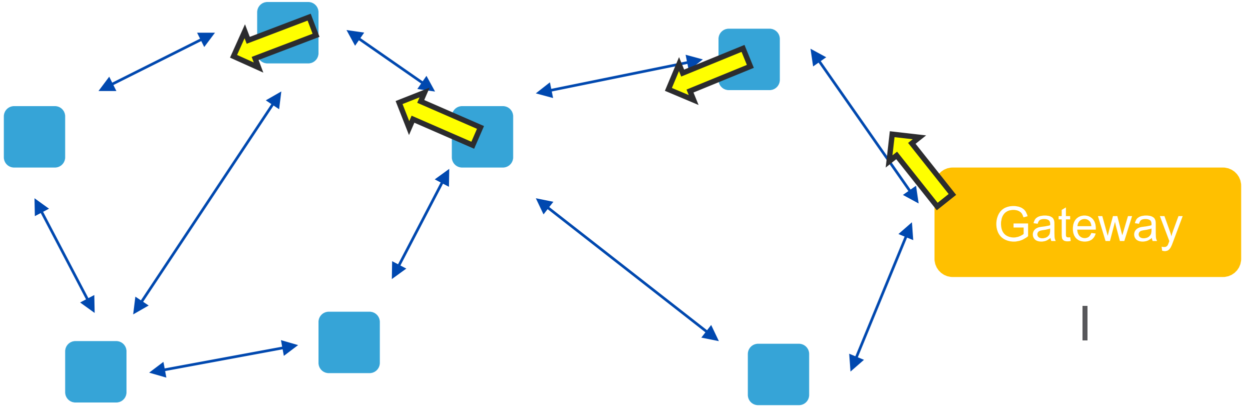

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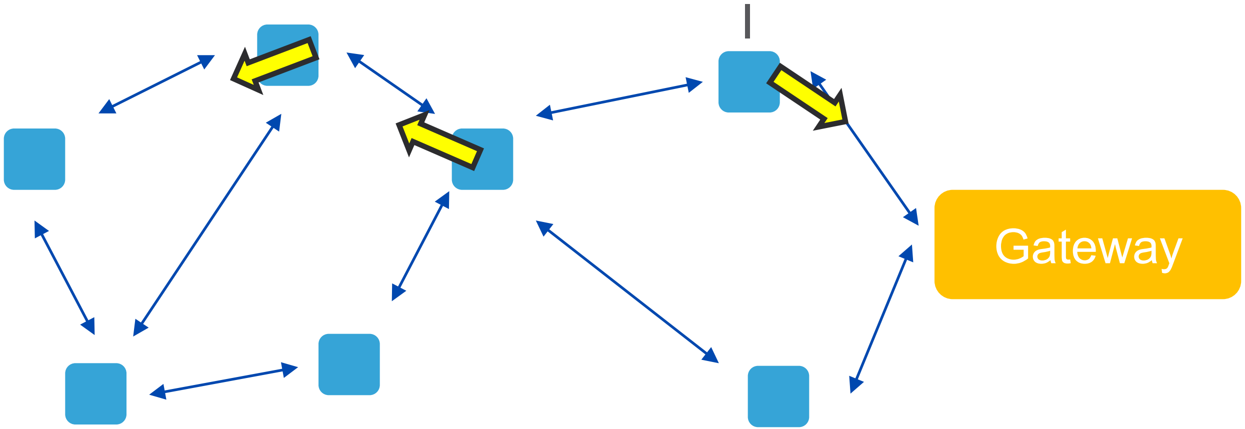

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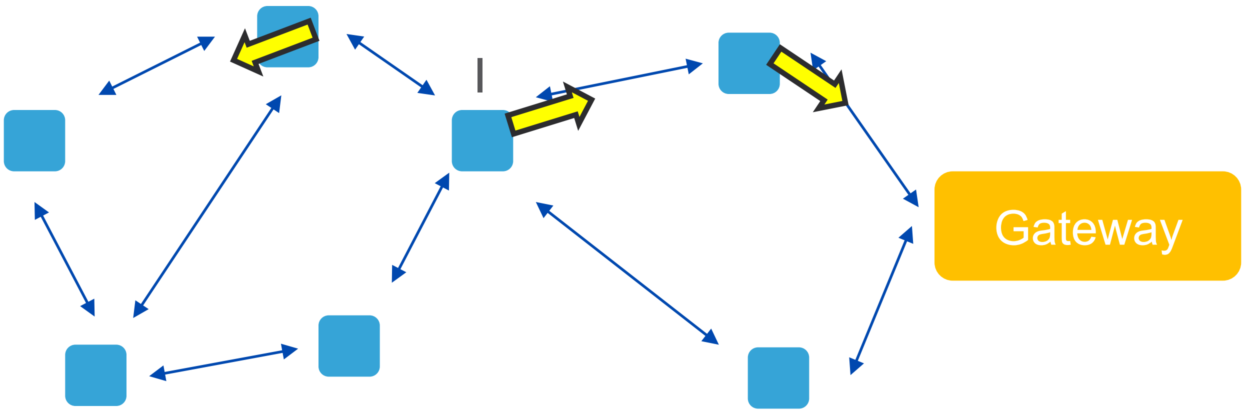

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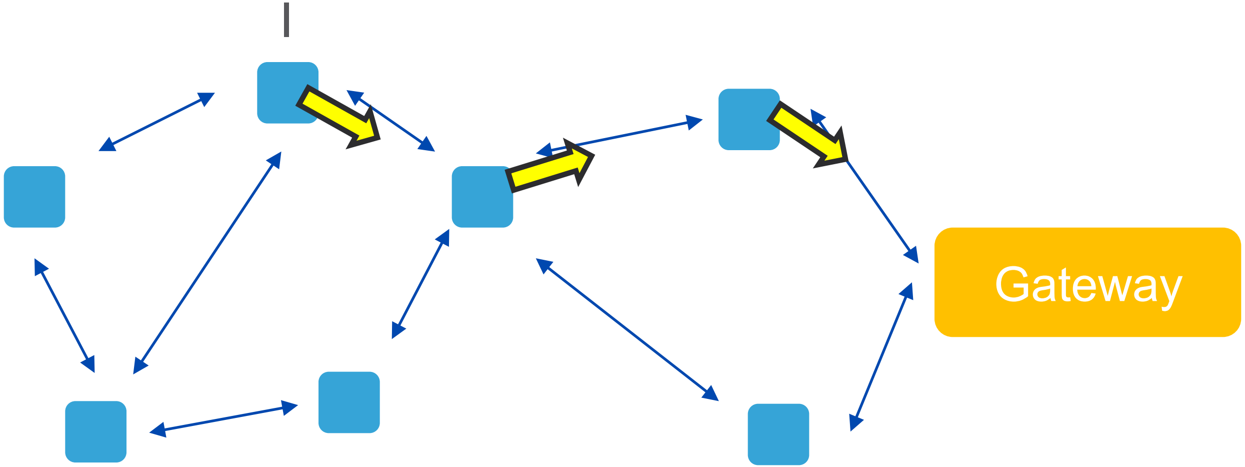

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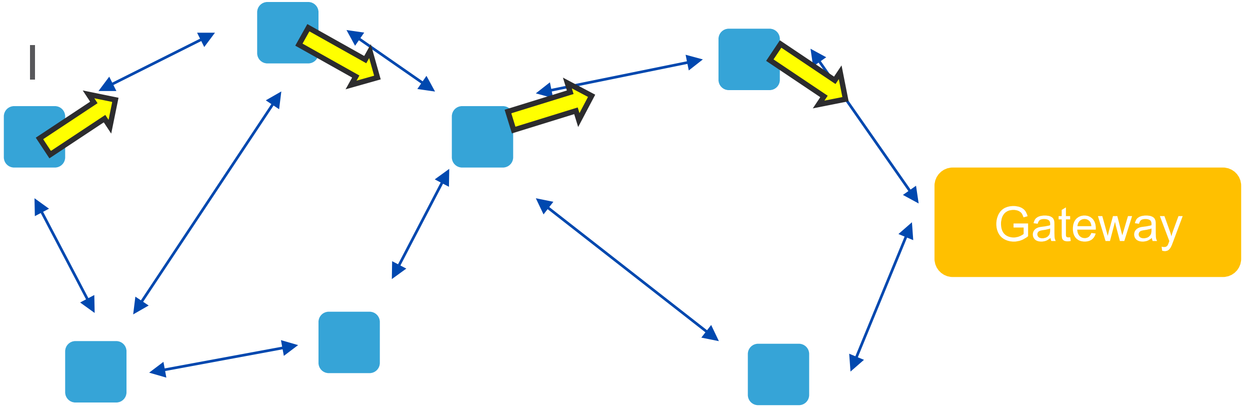

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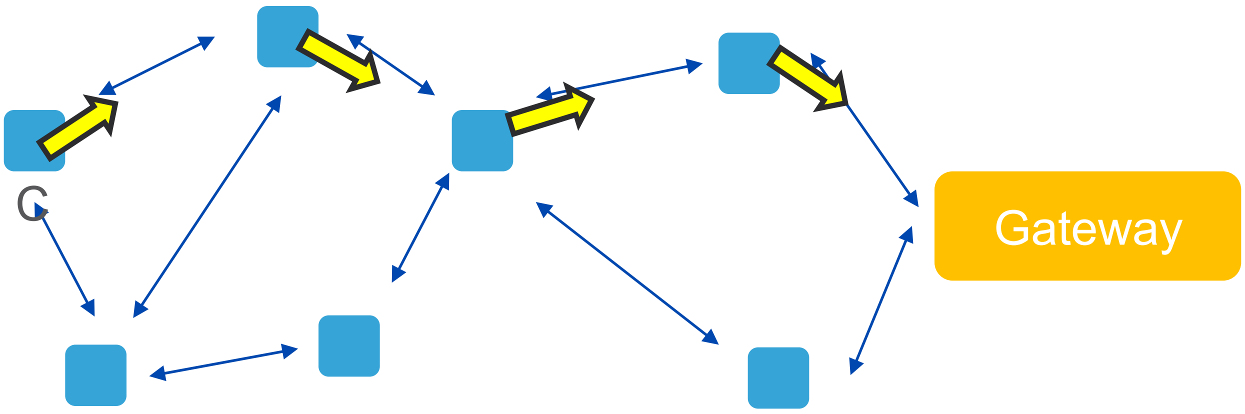

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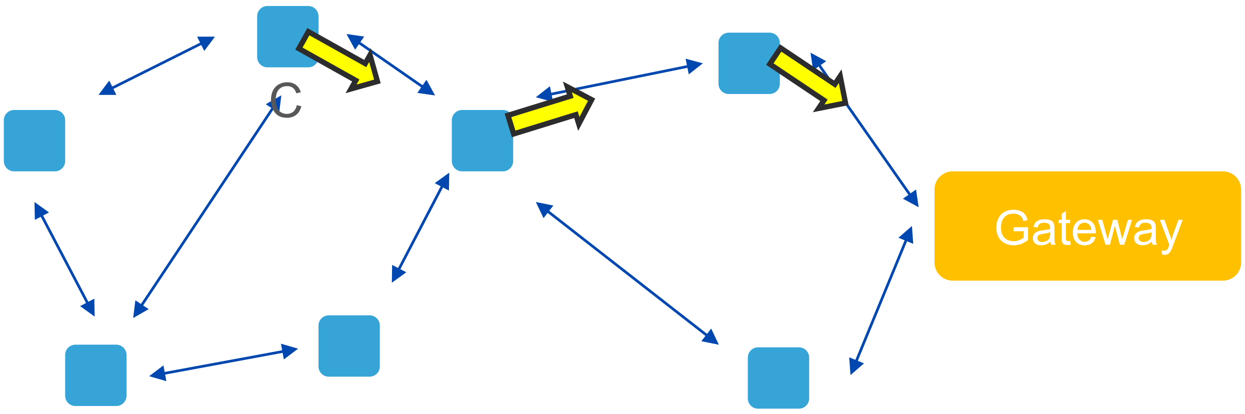

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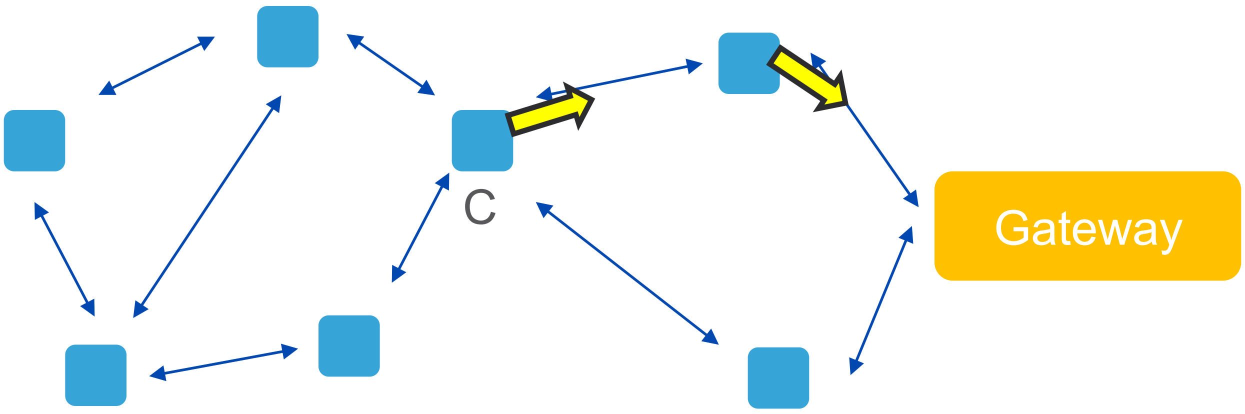

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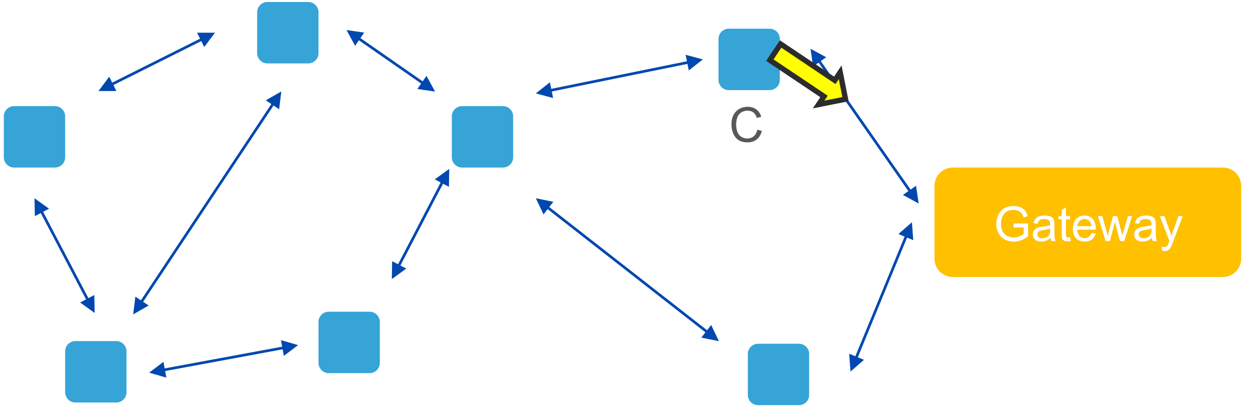

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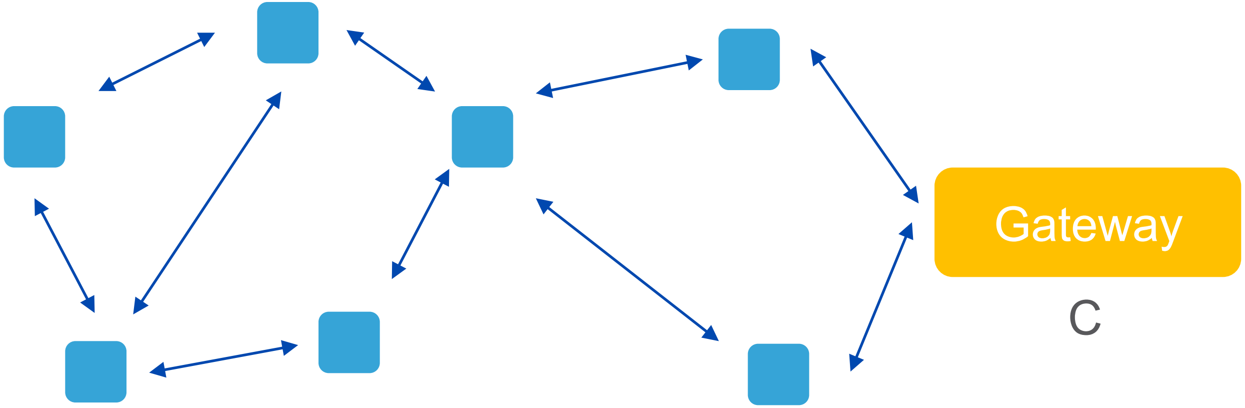
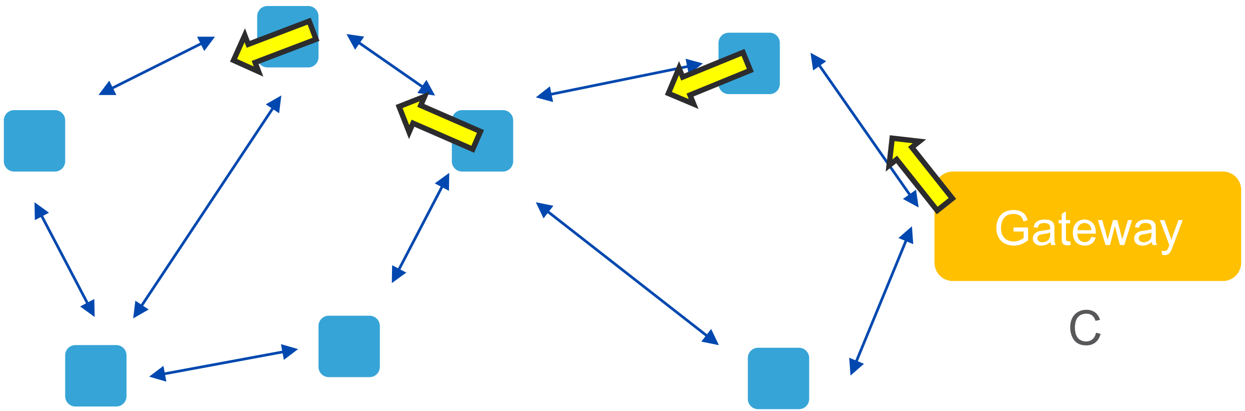


Dynamic Network Topology



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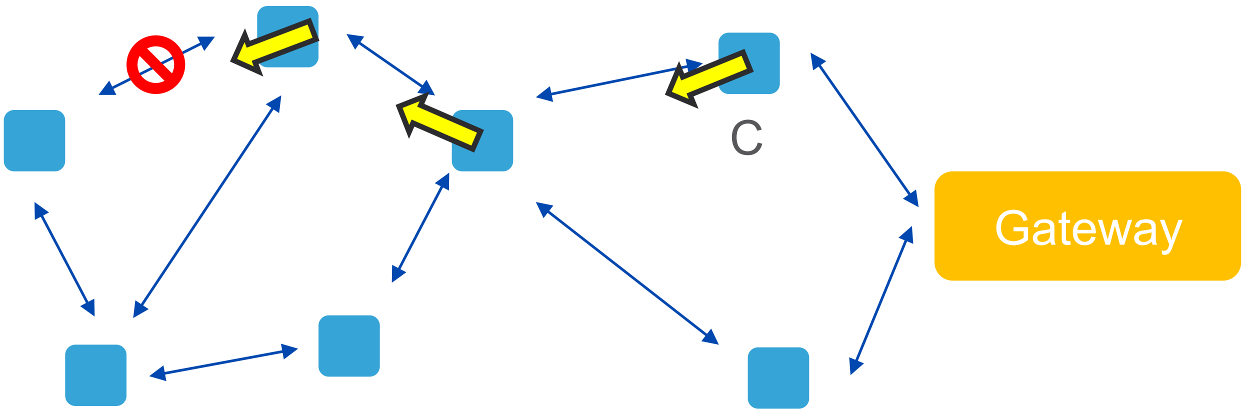

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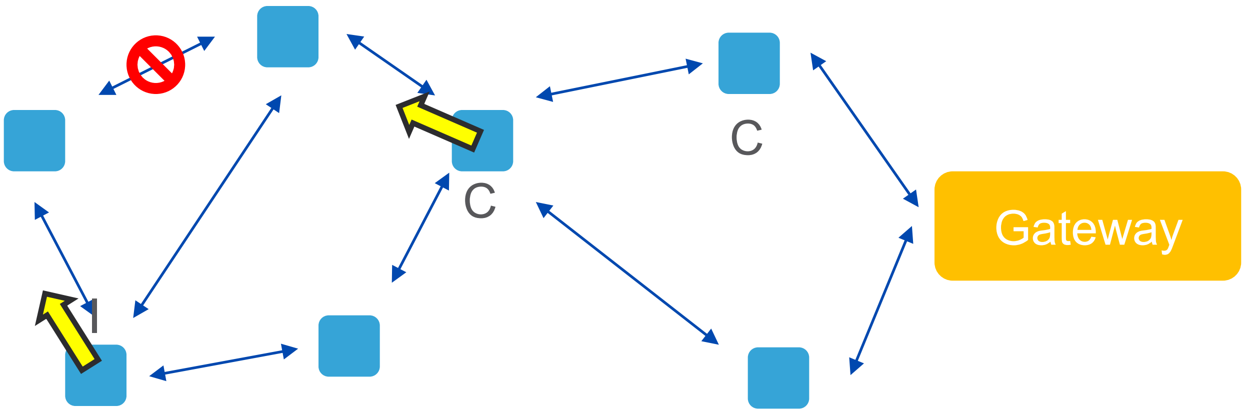

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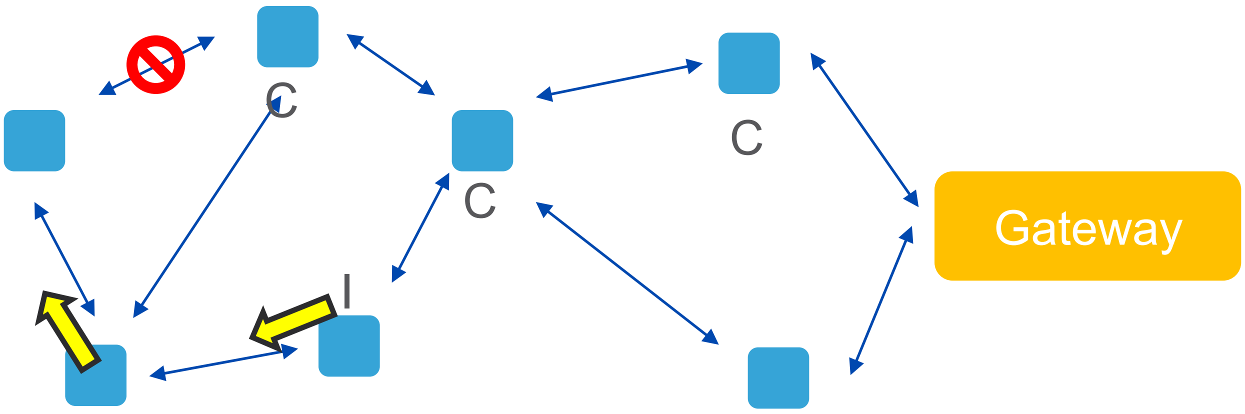

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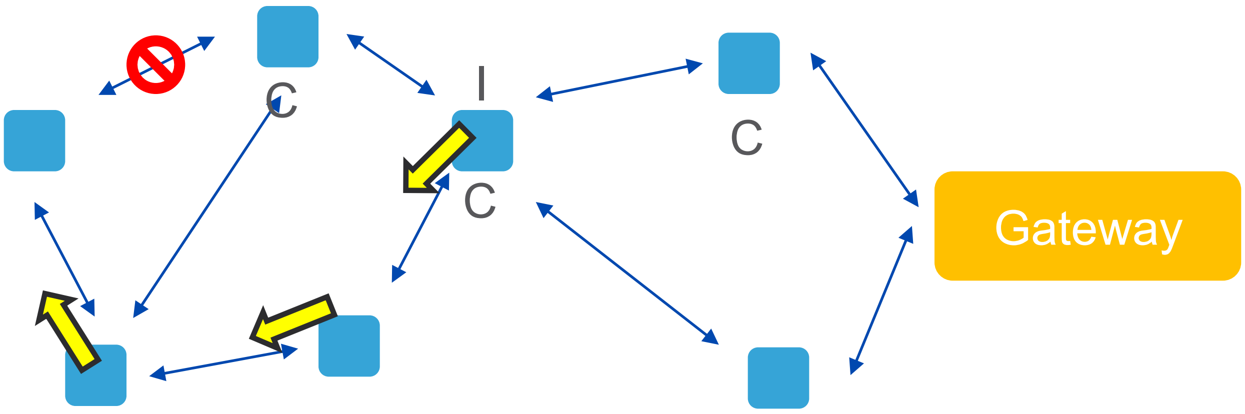

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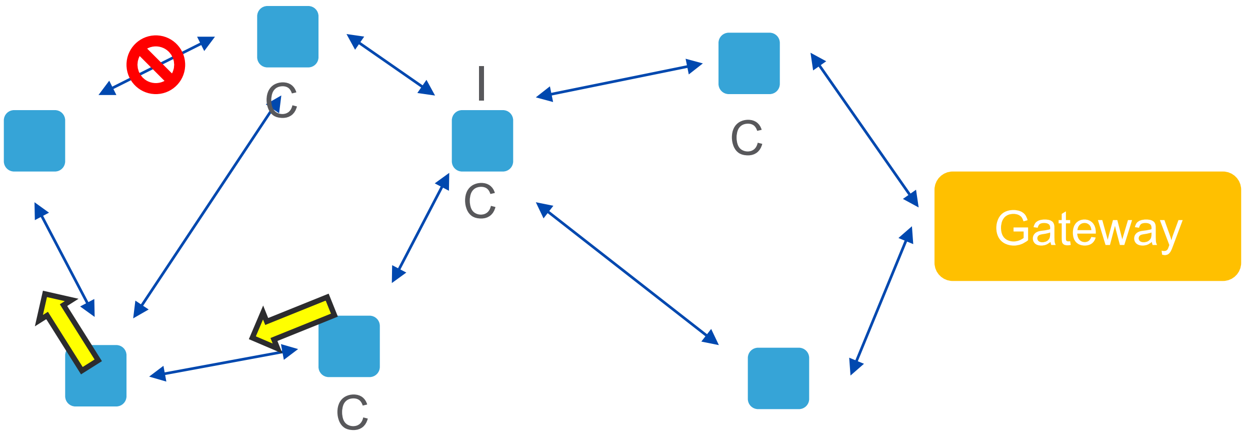

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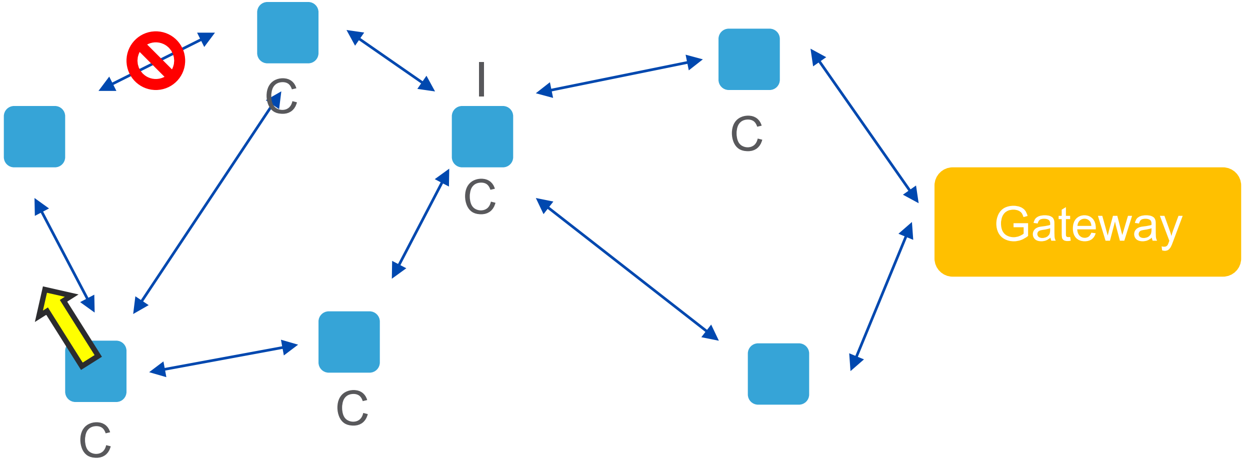

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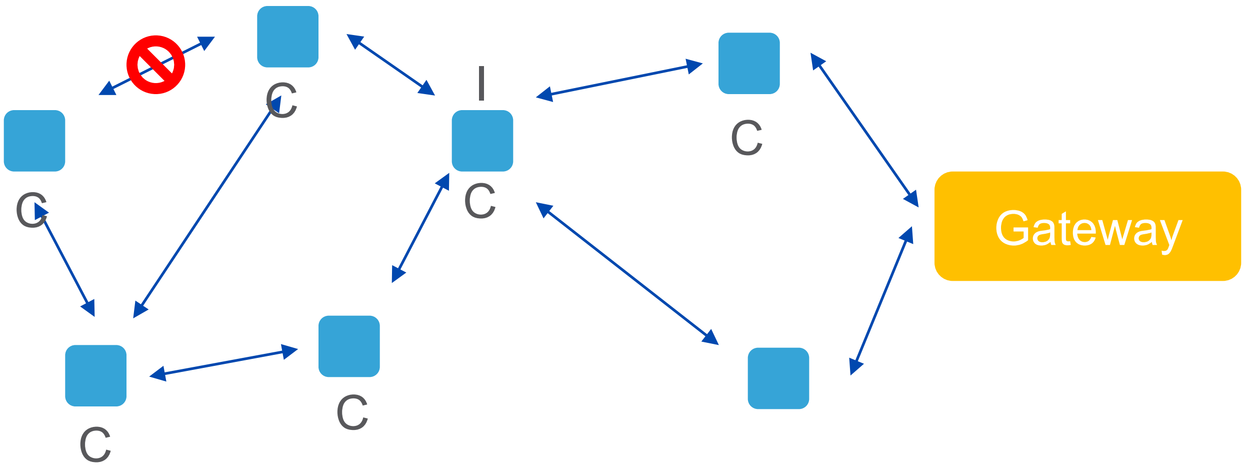
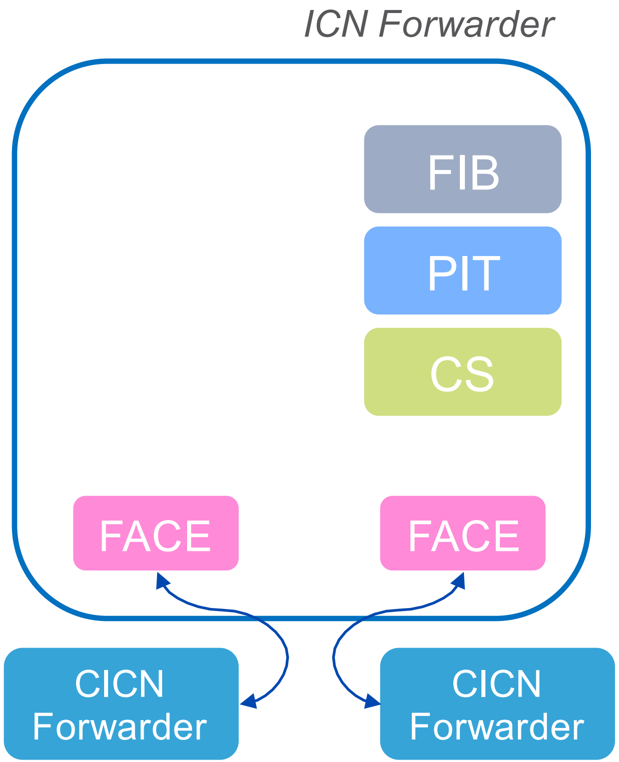


Cisco ICN Forwarder

FIB: Forwarding Information Base
PIT: Pending Interest Table
CS: Content Store
Face: Point-to-point association with another node

Background process:

- Beaconing
- Neighbor enumeration
- Link assessment
- Face management



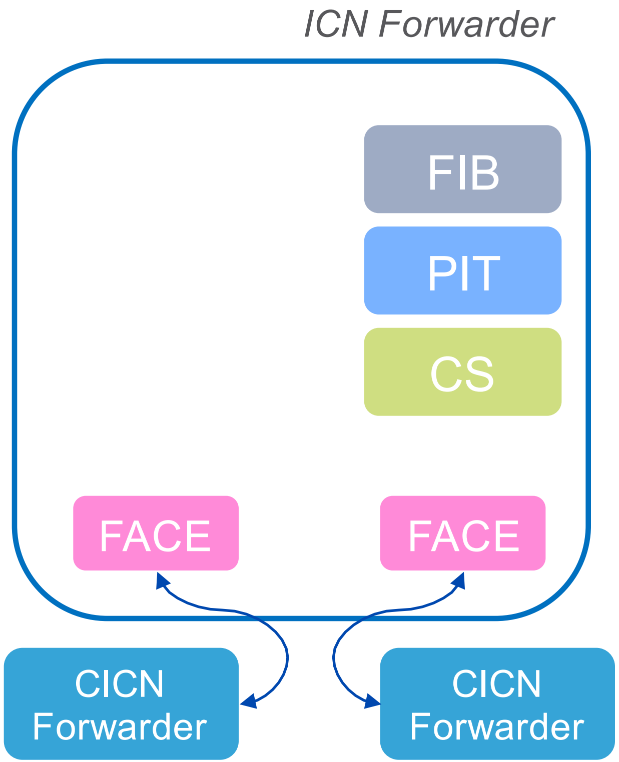
Cisco ICN Forwarder

Interest:

- Forwarder process receives Interest from RIOT driver
- Add PIT entry with Face ID
- If Content is in CS, return Content
- Look up Interest in FIB and forward to next hop

Content:

- Forwarder process receives Content from RIOT driver
- Add Content to CS
- Look up Content in PIT
- Forward to next hop, delete FIB entry



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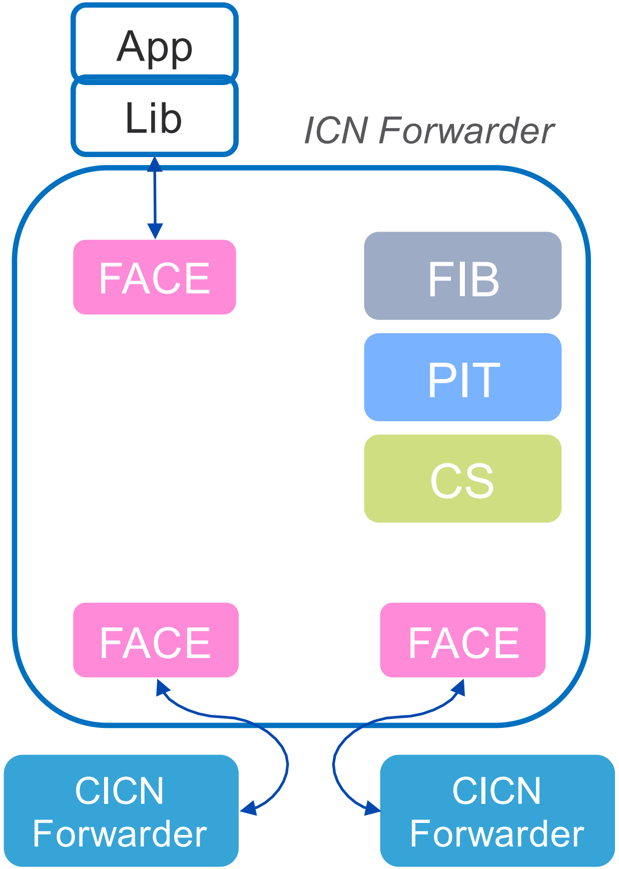
Cisco ICN Application

Consumer:

- App builds interest and send to Forwarder through Face
- Forwarder adds PIT pointing to App face
- Forwarder

Producer:

- PIT entry points to inbound Face
- Interest delivered to App through Face
- App generates Content, returns through Face
- Forwarder looks up PIT entry and forwards Content



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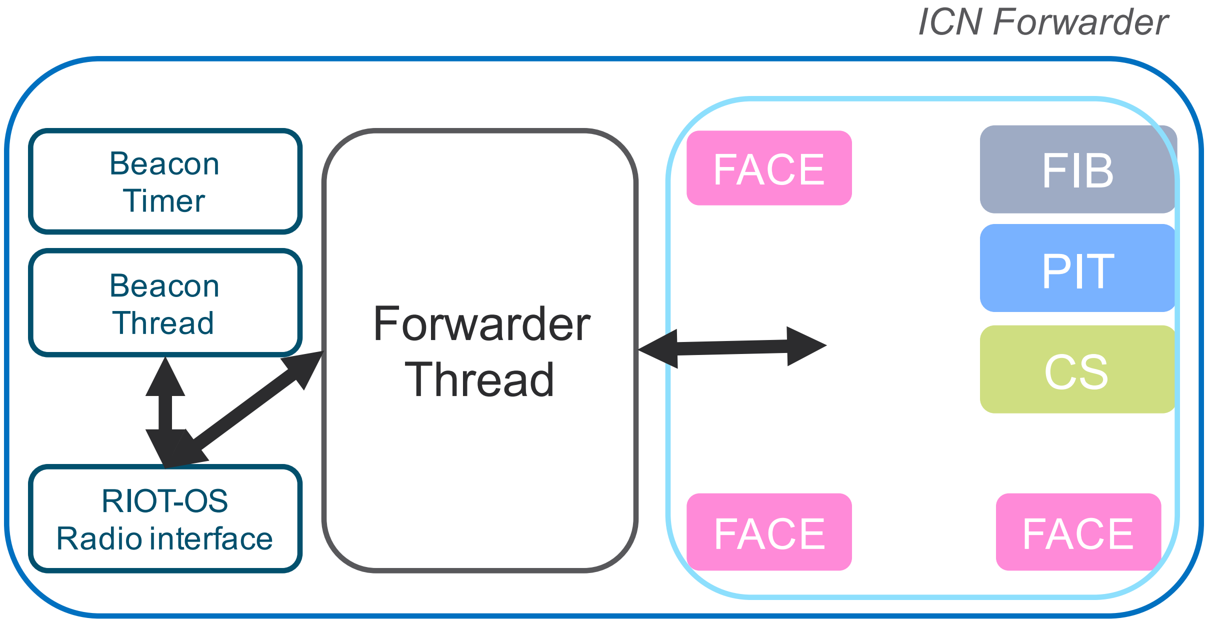
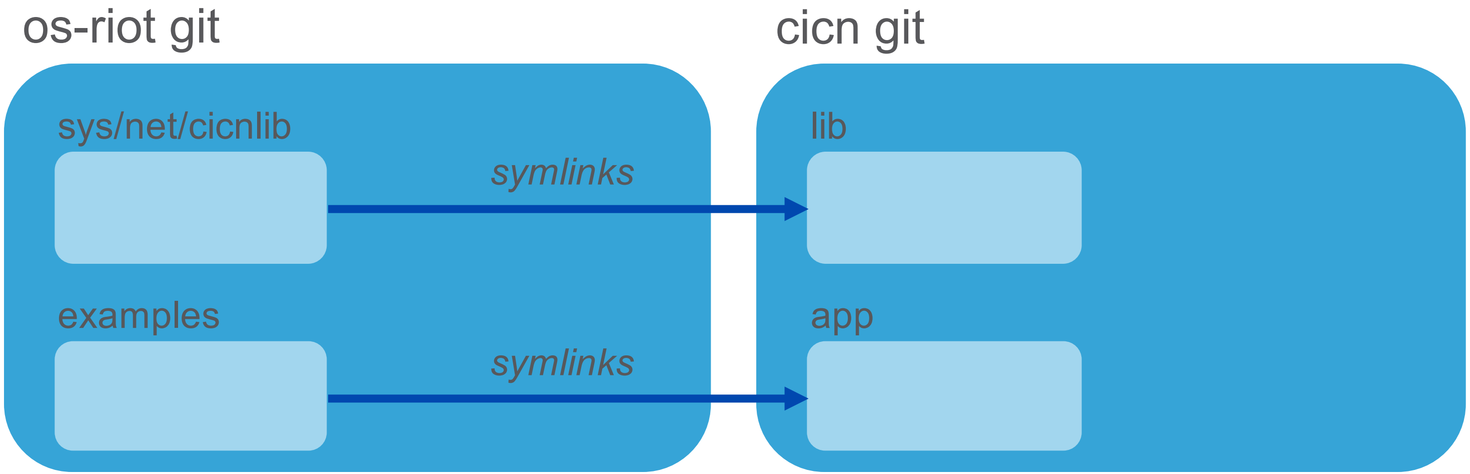
CICN Forwarder Implementation



Cisco ICN Forwarder Development



- Build the forwarder in the os-riot examples directory
- Makefile includes “USEMODULE += cicnlib”
- git updates require almost no manual intervention
- Targets: OpenMote, SAMR21-XPRO, (Cisco) Trifecta, Native

Securely Joining an ICN Network

- Joining a wirelese mesh network is first step in ZigBee-IP, WiSUN FAN
  - Authenticate and authorize joining node
  - Authenticate and authorize joined network
- How can secure join be implemented in ICN?
  - Assume authentication agent in gateway
  - Assume PSK between joining node and gateway
  - Neighbor node authenticates joining node and delivers network authentication to joining node

Comparison: ICN and ZigBee-IP

- Bytes over-the-air: 80% reduction
- Crypto operations: 10% increase
- Energy consumption: 50% decrease

Full paper to appear in ACM ICN 2016

A Software Platform for IoT

- Open source platform for constrained device development is key – think of ”Linux for IoT”
  - Requirements: good technology base, community dev process, support, wide base of supported platforms
  - Linux-based unsuitable
  - Examples: RIOT, Contiki, XINU

Insert RIOT logo here...

ICN and RIOT: a good match…

- Appropriate APIs: Network level interface
- Adaptable: easy to leave off entire IPv6 stack
- Application build support: integrated ICN libraries and application into existing RIOT build and update infrastructure
- Resulting forwarder/application fits comfortably in typical constrained device

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