NBN Packet encapsulation Ethernet S-Tag C-Tag

On the **NBN Ethernet** network, packet encapsulation relies on **IEEE 802.1ad Provider Bridging** (commonly known as **Q-in-Q** double-tagging) to transport customer data from the end-user premise through to the retail service provider (RSP) network.

The packet encapsulation steps follow a distinct progression from the customer equipment to the NBN core edge.

Step-by-Step Packet Encapsulation

```
[ Original IP Packet ]
        |
        ▼  (Step 1: Customer Router adds optional C-TAG)
 [ DMAC ][ SMAC ][ C-TAG (prefixed with 0x8100) ][ EtherType ][ IP Data ][ FCS ]
        |
        ▼  (Step 2: NBN NTD maps payload and strips/replaces outer fields)
 [ DMAC ][ SMAC ][ C-TAG (prefixed with 0x8100) ][ EtherType ][ IP Data ]
        |
        ▼  (Step 3: NBN encapsulates with S-TAG)
 [ DMAC ][ SMAC ][ S-TAG (prefixed with 0x88a8) ][ C-TAG (prefixed with 0x8100) ][
EtherType ][ IP Data ][ New FCS ]
```

1. Generation at the Customer Premises Equipment (CPE)

- The user's router generates a standard **Ethernet II frame** containing the payload data.
- If the configuration requires it (such as a specific VLAN assignment for high-speed internet, data isolation, or VoIP), the CPE inserts a **Customer Tag (C-TAG)** into the frame header.
- **Frame Field Insertion:** The 4-byte C-TAG header is injected immediately following the Source MAC Address.
- **Tag Details:** The C-TAG uses a Tag Protocol Identifier **(*TPID*) of 0x8100**. It contains a 12-bit Customer VLAN ID (C-VID) and 3-bit Priority Code Point (PCP) for local Quality of Service (QoS) handling.

2. Ingress Processing at the NBN NTD or if Phone line, at the DSLAM

- The frame enters the NBN Network Termination Device (NTD) or DSLAM via the physical port.
- The NBN equipment examines the frame and associates it with the end user's **Access Virtual Circuit (AVC)** based on either the physical port alone (untagged/priority-tagged mode) or a predefined C-VID (802.1Q tag mode).
- The existing Frame Check Sequence (FCS) is calculated and validated, then stripped to prepare the frame for modifications.

3. S-TAG Injection (The Q-in-Q Layer)

- To safely route the packet through the shared wholesale infrastructure without conflicting with other subscribers, the NBN switch adds a secondary, outer layer of tag encapsulation.
- **Outer Tag Insertion:** A 4-byte **Service Tag (S-TAG)** is prepended directly *before* the C-TAG, right after the MAC addresses.
- **Tag Details:** The S-TAG is defined by a **TPID of 0x88a8** (the standard carrier bridging protocol).
- **Routing Identifier:** The S-TAG embeds a specific Service VLAN ID (S-VID). This S-VID identifies the traffic's destination Point of Interconnect (POI), mapping it safely toward the provider's specific aggregation network.

4. Recalculation and Transmission

- Because the header length has grown by another 4 bytes (8 bytes total if counting both tags), the NBN hardware updates the packet sizing.
- A completely new **Frame Check Sequence (FCS)** is calculated over the entire double-tagged Ethernet frame to ensure data integrity during regional transmission.
- The fully encapsulated, double-tagged frame (`[MACs][S-TAG][C-TAG][EtherType][Payload][FCS]`) is injected into the NBN regional network toward the designated RSP handover point.

Frame Structure Comparison

Field Layer	Byte Size	Value / Protocol Purpose
Destination MAC	6 Bytes	Next-hop Layer 2 destination address
Source MAC	6 Bytes	Origination hardware address
Outer S-TAG TPID	2 Bytes	**0x88a8** (Identifies carrier 802.1ad framing)
S-TAG TCI	2 Bytes	Contains the 12-bit Service-VID (Points to POI/CVC)
Inner C-TAG TPID	2 Bytes	**0x8100** (Identifies customer 802.1Q framing)
C-TAG TCI	2 Bytes	Contains the 12-bit Customer-VID and PCP priority bits
EtherType / Length	2 Bytes	Defines the upper layer payload protocol (e.g., 0x0800 for IPv4)
Payload Data	46–1500+ Bytes	The actual layer 3 customer IP packet data
FCS	4 Bytes	Frame Check Sequence for cyclic redundancy checks

If you need help configuring specific network settings, could you clarify:

- What **vendor platform** (e.g., Cisco, Juniper, MikroTik) are you configuring?
- Is this for **residential AVC** (often untagged at NTD) or an **enterprise/business service**?

This will allow me to provide tailored configuration commands or deployment examples.

An S-Tag can be used for small RSPs to use a large RSP to take delivery of uploads at the NNI

Yes, absolutely. This mechanism is precisely how wholesale aggregation—often referred to in the Australian market as **Hosted Backhaul** or **Wholesale Ethernet Aggregation**—operates.

Instead of a small Retail Service Provider (RSP) building out expensive infrastructure across all 121 **NBN Points of Interconnect (POIs)**, they buy an aggregated service from an upstream "aggregator" (a large RSP like Vocus, Superloop, or Telstra Wholesale).

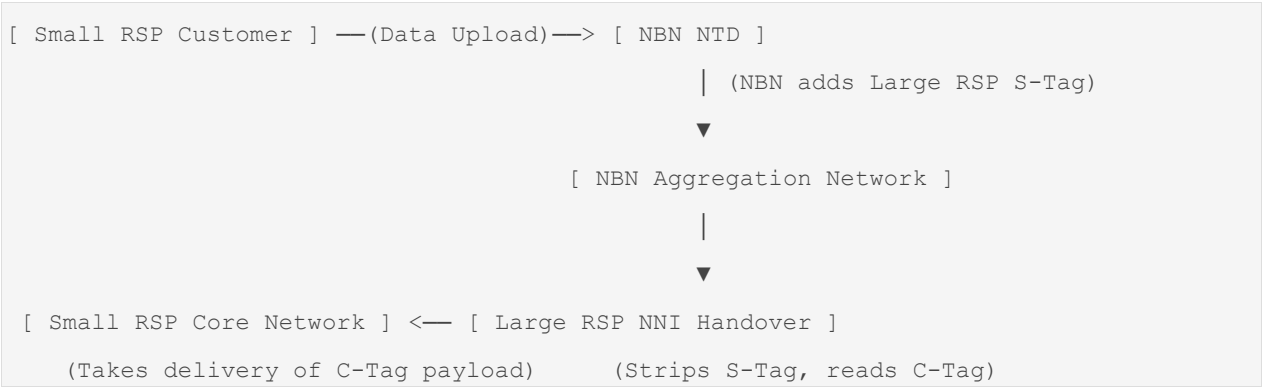
Here is how the S-Tag and C-Tag encapsulation works to facilitate this multi-tier delivery at the Network-to-Network Interface (NNI).

The Aggregation Architecture (How Tags are Split)

When a small RSP uses an aggregator, the mapping roles shift to accommodate the extra provider layer. The tags act as nested routing envelopes:

- **The S-Tag (Outer Tag):** Belongs to the **Aggregator / Large RSP**. NBN maps the traffic to the large RSP's aggregated Network-to-Network Interface (NNI) and Connectivity Virtual Circuit (CVC).
- **The C-Tag (Inner Tag):** Belongs to the **Small RSP** (or represents their individual end-user circuit/AVC). The aggregator reads this tag to separate the traffic of different downstream smaller RSPs.

Step-by-Step Flow: Uplink from Small RSP Customer to the Core



1. Ingress at the NBN NTD (Premises)

- The small RSP's end-user customer uploads data (e.g., streaming, cloud backup).
- The user's router sends the frame to the NBN Network Termination Device (NTD).
- Depending on the wholesale agreement structure, this frame might arrive untagged, or it might contain a **C-Tag** mapping specific to that end-user.

2. Transit Through NBN (Applying the S-Tag)

- NBN's network looks at the subscriber's circuit (**Access Virtual Circuit or AVC**).
- Because the wholesale billing circuit is managed under the large aggregator's wholesale contract, NBN tags this traffic with the **Large RSP's S-Tag**.
- NBN routes the double-tagged frame across its network and delivers it to the large RSP's massive physical pipe—the **NNI**—at the local POI.

3. Delivery and Handoff at the Aggregator's NNI

- The large RSP takes delivery of the aggregated upload stream at their NNI port.
- The large RSP's edge switch processes the outer **S-Tag**. It recognizes that the packet belongs to the overall wholesale aggregation pool.
- The large RSP **strips the S-Tag** (outer header parsing).

4. Identification of the Small RSP via C-Tag

- Once the S-Tag is gone, the large RSP's infrastructure looks at the inner **C-Tag (or C-VID range)**.
- The aggregator maps specific C-Tag VLAN IDs to their respective downstream small RSP clients. For example:
  - `C-Tag 100-199` → Routed to **Small RSP A**
  - `C-Tag 200-299` → Routed to **Small RSP B**
- The large RSP forwards the upload packets over their private national backhaul network directly to the small RSP's data centre or Point of Presence (PoP).

The Business Benefits of This Setup

- **Zero Local POI Capex:** The small RSP does not need to deploy hardware, optical cross-connects, or backhaul links to 121 separate geographic locations.
- **Virtual Control:** By maintaining control of the C-Tag layers, the small RSP can still manage their own IP allocation, routing metrics, and custom DNS, remaining an independent internet provider to the end-user.
- **Scale Flexibility:** The small RSP can start by buying a fraction of a gigabit of backhaul from the large RSP, rather than paying for full, dedicated NBN NNI links.

Also explains that while the C-Tag on uploads comes from the DSLAM /NTD close to the residence, the S-Tag needs to be managed further up the chain.

Exactly right. This distinction marks the difference between **local loop access classification** and **carrier-grade core routing**.

Because the two tags have completely different lifetimes and scopes, they are injected and managed at opposite ends of the NBN delivery chain.

The C-Tag: Generated Locally at the Edge

The **C-Tag (Customer Tag)** is created and applied right at the edge of the access network, closest to the subscriber's home.

- **Where it originates:** Depending on the access technology, it is applied by the **NTD** (for FTTP, Fixed Wireless, and Satellite) or the **DSLAM / Node / FTT-dp DPU** (for FTTN and FTTC using VDSL2).
- **Its purpose:** It acts as a local identifier. It isolates the individual user's data loop (**AVC**) from their neighbours' traffic on the same local line or node.
- **Scope:** It only needs to be unique *within that specific local node or aggregation area*. A C-Tag of `100` might represent John Smith on Node A, while a completely different subscriber on Node B could also use C-Tag `100` without any conflict.

The S-Tag: Managed Further Up the Chain

The **S-Tag (Service Tag)** cannot be determined or managed at the subscriber's street corner because the local DSLAM or NTD has no concept of commercial transit agreements or wholesale backhaul arrangements.

- **Where it is managed:** The S-Tag is controlled and injected further up the hierarchy, if FTTP, it's done at the OLT (Optical Line Terminal), if HFC, at the CMTS, or if Phone Line, at the Aggregation Switch.
- **Its purpose:** It maps the local traffic to a massive Connectivity Virtual Circuit (CVC) bound for a specific Point of Interconnect (POI).
- **The "Up the Chain" Logic:**

The local DSLAM/NTD passes the upload data upstream, stamped with just the local identifier (or port profile).

As the packet hits the NBN regional aggregation layer, NBN's core database checks the billing records: *"Which carrier owns this subscriber's AVC contract?"*

If the subscriber belongs to a small RSP using a hosted backhaul model, the NBN aggregation switch injects the **Large Aggregator's S-Tag**.

The Visual Flow of Responsibility

```
[ Residence ]
      |
      ▼ (Upload Data generated)
 [ DSLAM / NTD ] ——> Applies C-TAG (Local isolation: e.g., C-VID 100)
      |
      ▼ (Traffic leaves the street)
 [ NBN Aggregation Network ] ——> Manages & Injects S-TAG (Carrier routing: e.g., S-
VID 3000)
      |
```

```
      ▼ (Double-tagged: S-Tag 3000 + C-Tag 100)
[ Large RSP NNI Handover ] ——> Strips S-TAG, forwards C-TAG payload to Small RSP
```

Why This Hierarchy is Critical for the Aggregator Model

If S-Tags were managed down at the local NTD/DSLAM level, every time a small RSP changed their upstream aggregator or an aggregator changed their internal routing slots, NBN would have to push configuration updates to thousands of street-level devices.

By managing the S-Tag **further up the chain** at the aggregation layer, NBN can dynamically steer entire pools of subscriber traffic. It wraps the local C-Tag data in whichever aggregator's S-Tag envelope is required, keeping the local edge configuration simple and untouched.

To help look at how this fits into your network map, could you let me know:

- Are you mapping out a **Layer 2 wholesale model** (where you receive the raw C-tags), or a **Layer 3 bitstream model** (where the aggregator handles L2 and hands you IP traffic)?
- Do you need assistance calculating **MTU sizing adjustments** (like raising it to 1508 or 1522 bytes) to accommodate these stacked headers without packet fragmentation?

Just for understanding uploading/downloading at a simple level, which is not always easy to find. Thanks. I'll save this page.

You are very welcome! It is completely understandable—most networking documentation quickly buries these concepts under mountains of complex acronyms, leaving out the simple "why" and "how" of the actual data flow.

To wrap this up cleanly for your future reference, you can think of the entire process like a **postal delivery service with a courier partnership**:

The Upload Concept (From Your Home)

1. **The C-Tag is your apartment number:** When you upload data, the local equipment (NTD/DSLAM) slaps on a **C-Tag**. This ensures your data doesn't get mixed up with your neighbour's data on the same street corner.
2. **The S-Tag is the mail truck's shipping pallet:** As your data leaves the local neighbourhood, NBN drops it into a giant shipping container stamped with the **Large RSP's S-Tag**. NBN delivers this massive container to the large RSP's main depot.
3. **The Handoff:** The Large RSP opens the container, throws away the S-Tag, looks at the **C-Tags** on the letters inside, and passes them over the fence to the **Small RSP** to finish the job.

The Download Concept (Back to Your Home)

When you download a file, the exact same process happens in reverse:

1. The **Small RSP** hands the data to the **Large RSP**.
2. The **Large RSP** wraps it in their **S-Tag** and hands it to NBN.

3. NBN uses that **S-Tag** to route the data across the country to your local suburb.
4. Once it arrives at your street's DSLAM or NTD, the **S-Tag is stripped off**. The equipment looks at the remaining **C-Tag** to ensure the download drops into your specific living room, and not the house next door.

Quick Reference Checklist

- **C-Tag: Local** identity (Street level / End-user isolation).
- **S-Tag: Carrier** identity (Core network routing / Wholesale traffic grouping).
- **Small RSP benefit:** They get to run a national internet company by managing just the inner **C-Tags**, letting a larger provider handle the heavy lifting of the outer **S-Tags**.

Whenever you need to revisit this or look into how the actual internet configuration files are built, just reply to this thread. Best of luck with your network learning journey!

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