CSN & 802.11 BSS Bridging

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IEEE 8021 Interim Meeting, Santa Cruz, CA Sep 2012
new-phkl-11-bbs-bridging-0812-v4
The issue

• 802.11 non-AP STA devices are end devices that do not bridge to external networks. This:
  – limit the topology of 802.11 BSS to “stub networks”
  – do not allow a (STA-)AP-STA wireless link to be used as a connecting path (backbone) between other networks

• Partial solutions exist to overcome this lack of bridging functionality but these solutions are:
  – proprietary only
  – limited to certain type of traffic
  – or/and based on Layer 3 (such IP Multicast to MAC Multicast translation, NAT - Network Address Translation)
Coordinated Shared Network (CSN)

- Contention-free, time-division multiplexed-access, network of devices sharing a common medium and supporting reserved bandwidth based on priority or flow (QoS).
  - one of the nodes of the CSN acts as the network coordinator, granting transmission opportunities to the other nodes of the network.

- Physically a shared medium, in that a CSN node has a single physical port connected to the half-duplex medium, but logically a fully-connected one-hop mesh network, in that every node can transmit frames to every other node over the shared medium.

- Supports two types of transmission:
  - unicast transmission for point-to-point (node-to-node)
  - transmission and multicast/broadcast transmission for point-to-multipoint (node-to-other/all-nodes) transmission.
Heterogeneous Network Bridge Model

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Heterogeneous Network Bridge Model - 1

Bridge of \((k+m+p+f)\) Heterogenous Ports

- **802.3 MAC/PHY**
  - Ethernet Ports
  - \(k\) Ports

- **MoCA MAC/PHY**
  - MoCA Bridging Table (MAC Address, NID)
  - \(m\) Virtual Ports

- **1901 MAC/PHY**
  - 1091 Bridging Table (MAC Address, TEI)
  - \(p\) Virtual Ports
  - 1901 Bridging Protocol

- **FOO MAC/PHY**
  - FOO Bridging Table (MAC Address, DID)
  - \(f\) Virtual Ports
  - FOO Bridging Protocol
Hidden Nodes...

- On **both** 802.11 and 1901 networks, nodes could be hidden to other nodes...
- …but both 802.11 AP and 1905.1 CCo see all nodes
CSNs behave as L2 Bridges…

L2 Bridge

CSN Network

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CSN as Distributed Bridge - Pros

- **Scalable:**
  - Single bridge per CSN regardless # of nodes
    vs P2P mesh where each node is a bridge

- **Optimized for “heavy”/”light” nodes**
  - (single ctrl plane node + n-1 “dumb” ports rather than n bridges)

- **No duplication of resources**
  - 1 single Ctrl plane entity per CSN

- **Reuse of standard L2 Ctrl protocol entities**
  - requires only a simple adaptation layer
    (cf “White Paper: Control Plane Implementation on Coordinated Shared Networks (CSN)”

- **Support ranking**
  - without modification of the underlying network protocol

- **Network agnostic interface to underlying network**
  - simple interface
  - CSN bridging method is kept “internal” *(including “node relaying” when applicable)*

- **This model is already used by MSRP for CSN and 802.11 BBS (IEEE 802.1Q-2011, Annex C)*
Selected Node Architecture

- Route BPDU to BP service
- Provide BPDU with CSN network topological information

BP Service
- BPDU
- Node IDs
- QoS Cmd

Device Management

Ethernet Port

MAC

PHY

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BPDU Propagation over CSN

Ingress Node i
- **Ethenet CSN**
- **BPDU**
- **MC Frame**
  - **BPDU**
  - **I_NID**
  - **D_NI**

Selected Node d
- **BPDU**
- **BPDU Ctrl Frame**
  - **BPDU**, **I_NID**

BP Service
- **BPDU Msg & Ingress Node ID**

Egress Node e
- **Ethenet CSN**
- **BPDU**
- **CSN Unicast MPDU**
  - **E_NI**
  - **D_NI**
  - **BPDU**

- **Port_Cmd**

Egress Node f
- **Ethenet CSN**
- **BPDU**
- **CSN Unicast MPDU**
  - **F_NI**
  - **D_NI**
  - **BPDU**

- **Port_Cmd**
A) Talker MSRPDU flow

(Talker) MSRPDU

CSN QoS BW query protocol

Designated MSRP Node (DMN)

MSRP Entity

CSN QoS BW Query primitive

CSN QoS Response

(Listener(s)) MSRPDU

B) Listener MSRPDU flow

(Listener) MSRPDU

CSN QoS BW Reservation primitive

Downstream Node

DMN

MSRP Entity

CSN QoS BW rsv protocol

CSN QoS Response

(Talker) MSRPDU

Upstream Node
Heterogeneous Network Bridge Model - 2

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GW Centric Home Network – Bridge Model

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Heterogeneous Networks are Bridged LANs

- 802.11 BSS handled as other CSN networks
Set of point-to-point links

- The Access Points and their co-resident bridging functions become integrated AP bridges (AP/Bs).
- Devices with non-AP station capability(ies) and wired connections become “non-AP station bridges” (S).
- Of course, not all stations are bridges. (The diamonds are non-bridge non-AP stations.)


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802.11 LAN emulation

- Each AP and its stations emulate a shared medium LAN (fat yellow coax), as seen by the wired bridges.

- Each AP uses its bridge knowledge to optimize forwarding through the 802.11 medium, rather than broadcasting every frame.

- Direct AP-AP links have to be modeled separately from "coax". Station-station links can be separate (shown) or part of emulated LAN.


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- Each BSS (Access Point and its non-AP stations) emulate a single, separated bridge [B1] [B2].
- An AP with wired connections is logically separated into an BBS bridge port (AP) and a wired bridge (B).
- Each non-AP station/bridge is logically separated into an BSS bridge port and a (virtual) wired bridge (B) (with wires to each component).
BSS Bridging Model

Virtual Ethernet Bridge/802.11 Basic Service Set

STA Bridging Mode of Operation
To DS=1, From DS=1
BSS Bridging Model (Single Ctrl Plane)

**L2 Bridge Protocol**

**Ctrl Entity**

**Access Point**

**Bridging Table**

**Control Plane**

**BPDU**

**Port Ctrl (Action Frame)**

**Virtual Ethernet Bridge/802.11 Basic Service Set**

**STA Bridging Mode of Operation**

To DS=1, From DS=1

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AP Bridging

Bridging Table

<table>
<thead>
<tr>
<th>DA</th>
<th>RA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC_1</td>
<td>MAC_2</td>
</tr>
<tr>
<td>MAC_5</td>
<td>MAC_4</td>
</tr>
</tbody>
</table>

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BSS Bridging

- The whole BSS is modeled as a distributed bridge overlaying the 802.11 protocol
  - AP acts as the Bridge’s Control Plane
  - Non-AP Stations act as Bridge Ports

- Modifications to 802.11 are limited to:
  1. \([\text{ToDS}=\text{Set}, \text{FromDS}=\text{Set}]\) mode behavior redefined at ingress AP and ingress non-AP Stations
  2. Broadcast “Echo Cancellation” Method <TBD>
     Could be:
     - APs broadcast MSDUs without modifying the Sequence Number & non-Stations filter out broadcasted MSDUs they originated on SN matches
     - Non-Stations filter out broadcasted MSDUs they originated on TID matches
  3. Additional Parameters to MLME-DLS primitives
Addition to the 802.11 Standard

• New Element in Beacon and Probe Response
  – AP indicates its BSS Bridging Capability in a new BSS Bridging Element in Beacon and Probe Response
  – AP BSS bridging Capability is controlled by a dot11BSSBridgingCapabilityEnabled parameter

• New Action Frames <TBD>
  – AP control to non-Station ports (i.e. block port…)
New [To DS = Set, From DS = Set] Handling

- Non-AP Station originated MSDU received by AP:
  - AP performs a lookup to the AP Bridging table with the Destination Address (DA) to retrieve the MAC address of the non-AP Station bridging the DA and use it as the Receiver Address (RA) of the forwarded MSDU
  - MSDU with unknown or Multicast DA addresses are broadcasted by the AP

- AP originated MSDU received by non-AP Station:
  - If the DA is a Broadcast/Multicast Address, the non-AP Station checks the MSDU Sequence Number or TDI (to match any of the SNs (or TIDs) of the latest Multicast MSDUs by this non-AP Station:
    - If match, the non-AP Station discards the receive frame
    - Otherwise the non-AP Station extracts the (DA,SA) and uses them as the (DA,SA) of the MSDU bridged by the non-AP Station
New DLS Bridging Traffic Type

Virtual Ethernet Bridge/802.11 Basic Service Set

1. Node (SA) to Non-AP Station (TA) via DLS wireless
   - MLME_DLS Rq (DA)
   - BSSID

2. Non-AP Station (RA) to Non-AP Station (DA) via DLS wireless
   - MLME_DLS Rq/Rsp
   - Bridge

3. Node (SA) to Non-AP Station (TA) via DLS wireless
   - RA

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• For Direct Link Setup mode, a new MLME-BDLS request primitive could be specified with the DA MAC address replacing the non-AP Station MAC address as parameter:

MLME-BDLS.request (PeerDAMACAddress, DLSTimeoutValue, DLSResponseTimeout)

• The associated confirm primitive returns the non-AP Station MAC address bridging the DA MAC address:

MLME-BDLS.confirm (PeerDAMACAddress, PeerSTAMACAddress, ResultCode, CapabilityInformation, DLSTimeoutValue, SupportedRates)
GW Centric Heterogeneous Home Network

GW

WAN

CoAx (MoCA)

AP 802.11 2.4 Ghz

AP 802.11 5 Ghz

PLC - 1901

802.3

N1

N2

N3

N4

N5

N6

802.3

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GW is the Designated Node for each CSN: CSN Bridge Data Planes are co-hosted on the GW
• For Network **Control** Protocols (such RSTP)
  - Each CSN bridge runs its own control plane
  - Same 802.1 standard protocol entity instantiated per CSN bridge

  ![Diagram of NCP entities and APIs](image)

• For Network **Service** Protocols (such MSRP)
  - A single control plane for all the CSNs
  - NSP primitives mapped to each CSN specific APIs

  ![Diagram of NSP entities and APIs](image)
GW Centric Data Plane

- Optimized case for IS-IS:
  - Single IS-IS Database
  - Immediate topology change “propagation”
    - Immediate coherency
    - No traffic overhead between bridges
    - Optimized resource
Thank You

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