MAC Address Issues in IEEE 802.1

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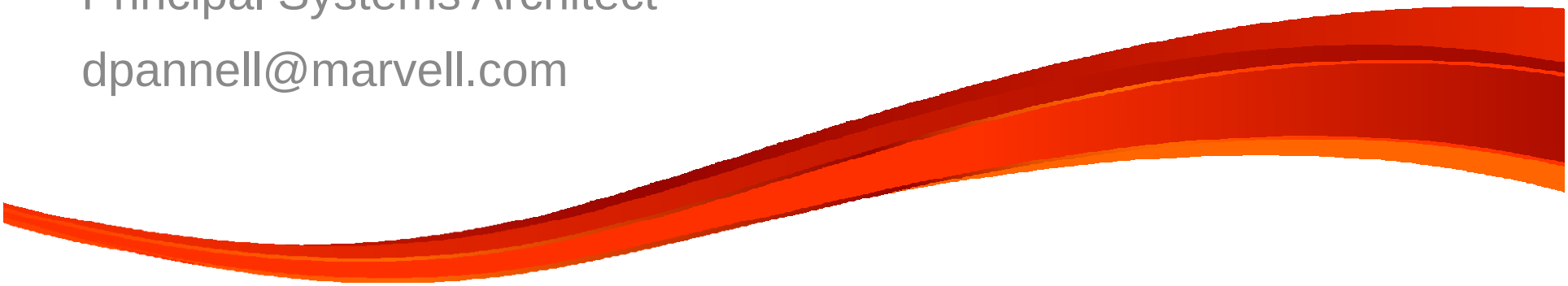

San Antonio, TX IEEE 802.1 Meeting

November 2014

Agenda

- Start out with my “The Looming Ethernet MAC Address Crisis” presentation given at the 4th Ethernet & IP Tech Day conference for Automotive in Detroit, MI last month.
  - This will give a foundation of the issue
  - And why the new Automotive use of Ethernet can easily adopt new methods
- Move to what IEEE 802.1 can do to help this issue – Now
  - We have to help the industry with our experience
  - Short term new methods will be easier to adopt with new markets such as AVB & TSN
- Long term Ideas . . .

The Looming Ethernet MAC Address Crisis

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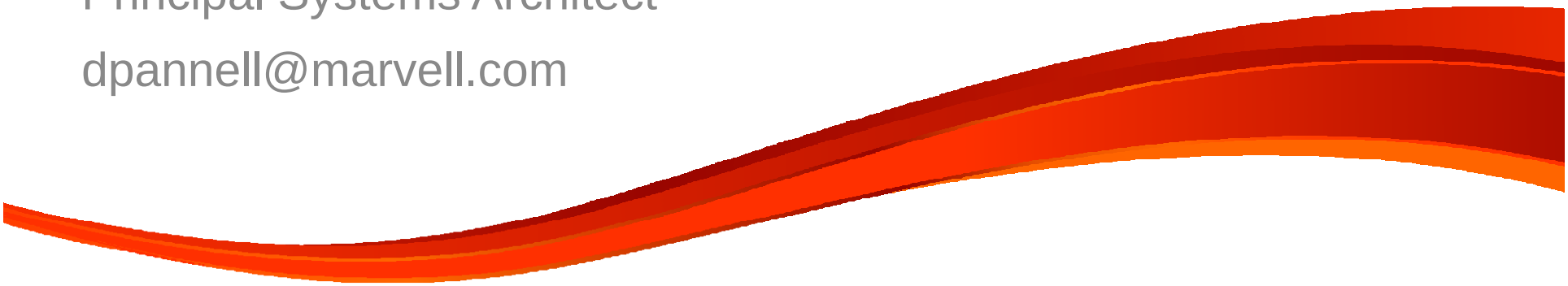

Ethernet & IP Automotive Tech Day

October 2014

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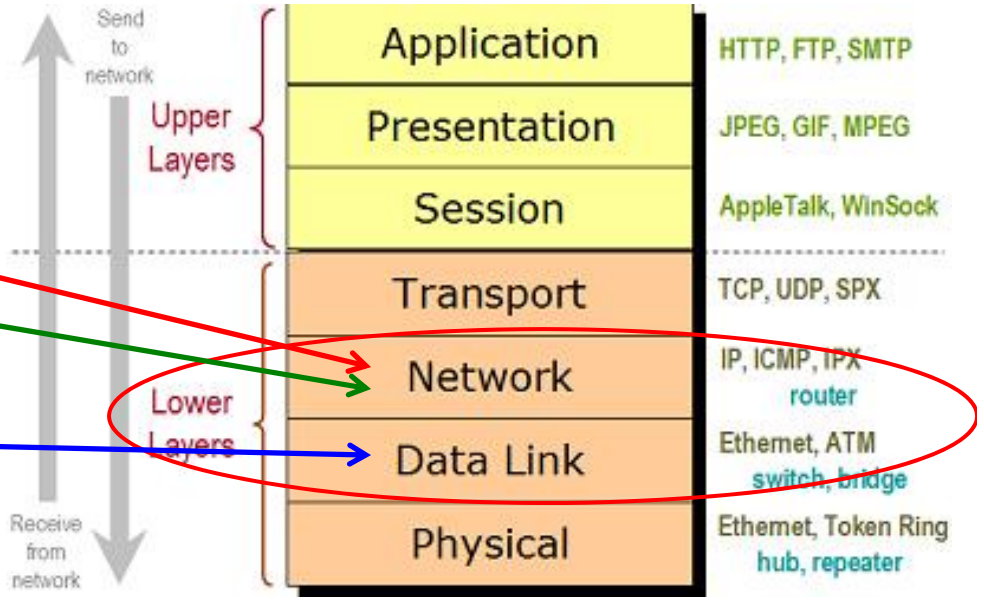
What Ethernet MAC Address Crisis?

- Didn't IPv6 solve the addressing problem?
- No!
- IPv6 solved the addressing problem at the IP Layer
  - The Network Layer
- But Ethernet is at the Data Link Layer and has its own separate addresses
  - IPv4 uses 32-bit addresses
  - IPv6 uses 128-bit addresses
  - Ethernet uses 48-bit addresses

The OSI Model of Computer Networks



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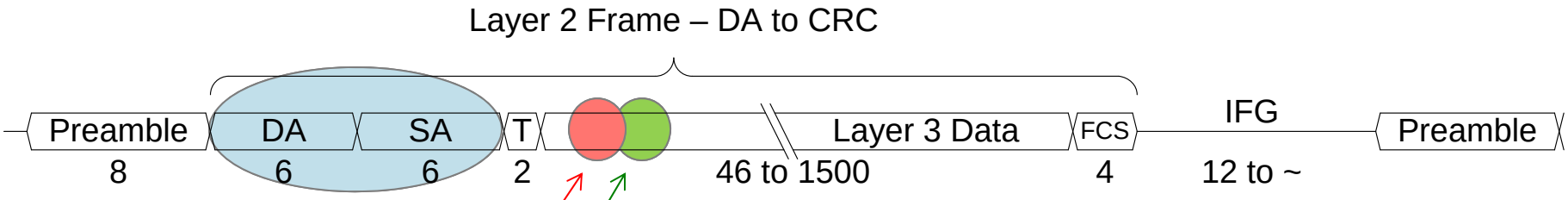
Reference: The Basic Ethernet Frame



- Preamble - the last Preamble byte is called the SFD (Start of Frame Delimiter)
- **DA: 6 byte Destination MAC Address**
- **SA: 6 byte Source MAC Address**
- T: 2 byte Ether Type – If its less than 0x0600 it's a Length
- Data: Variable size Layer 3 portion of the frame
  - This is the portion of the frame most software people are aware of
  - The IPv4/IPv6 Addresses are contained in the Header of this Data field
  - IEEE 1722 documents its frame formats starting with byte 0 of this Data field
- FCS: 4 byte Frame Check Sequence (a 32-bit CRC)
- IFG: 12 or more byte Inter Frame Gap

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Isn't 48-bit Addressing Enough?

- It Has Been for the first 34 years of Ethernet
- With Ethernet's success and the lower cost of technology, the Use Rate of Ethernet MAC addresses is increasing
- Think about it. How many MAC Addresses did you use in 1998? Typically less than 5:
  - Work computer, home computer, a laptop. . .
- Move to 2014. Now how many MAC Addresses do you use? Typically 10 to 15:
  - Cell phone, IP phone, laptop (2 – 1 for wired, 1 for wireless), laser printer (2 – same reason), set top box (2), TV, BluRay player, tablet, computer at home (2), wireless AP, . . .
- These MAC Addresses are 'consumed' in these products you buy even if you *never* use all their interfaces!

The Use Rate is Only Going Up!

- How many MAC Addresses will you use in 2025?
- With Ethernet in automotive it could be near 100 or more depending upon how many ECU's need MAC Addresses
- With LED Lighting in buildings and homes there is a desire to be able to control each fixture – that's a lot more MAC Addresses, one per fixture
- Some have even talked about Ethernet sprinkler heads with individual control so that water is not wasted
- Embedded, low cost, Ethernet devices are here today. There will more and more of them in the future

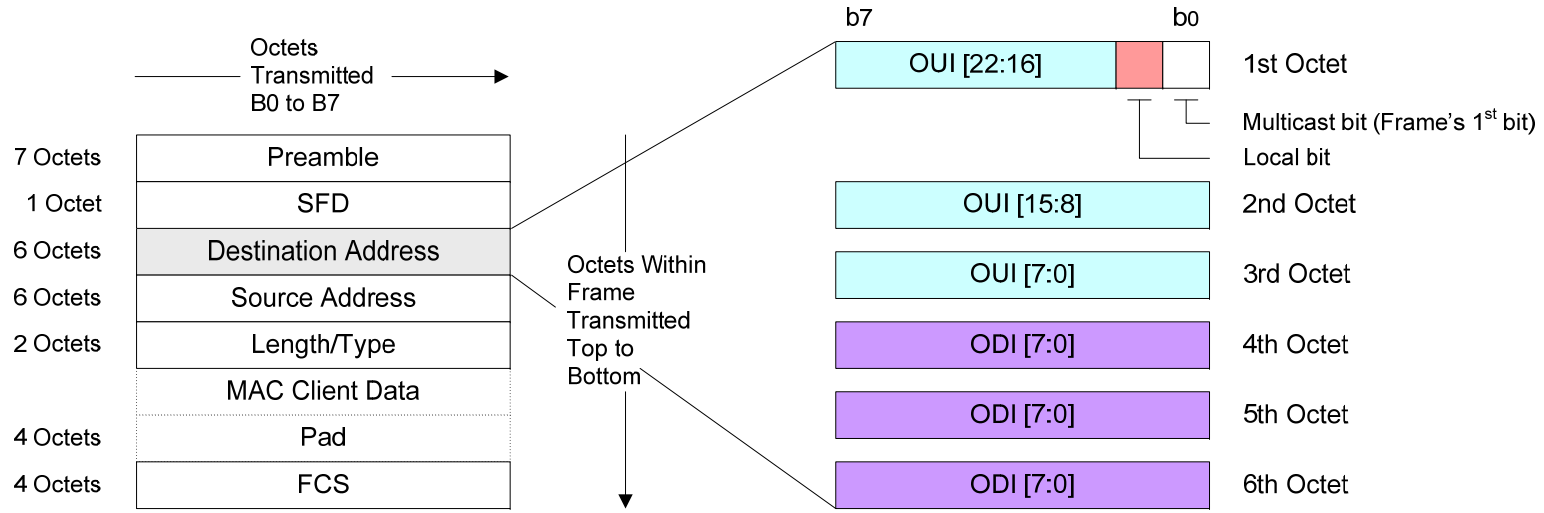
Why is the Use Rate a Problem?

- Simply stated:

  Ethernet MAC Addresses are a limited resource!

- Once used, Ethernet MAC Address can't be re-used – ever!
  - This includes all MAC Address purchased from the IEEE
- IEEE acquired MAC Addresses are Globally Unique
  - MAC Addresses that are not at least locally unique (i.e., duplicate addresses) cause IEEE 802.1 Bridges (switches) to improperly map frames
  - Using Globally Unique addresses provides one way to ensure MAC Addresses are locally unique.

The Original MAC Address Format



IEEE 802.3 Frame **MAC Format**

- ODI: 24-bit Organizational Defined Identifier (uniqueness by the Organization)
- OUI: 24-bit Organizational Unique Identifier (purchased from IEEE)
- Multicast bit: 1 → Multicast, 0 → Unicast
  - 01:02:03:04:05:06 is a Multicast address – bit 0 of '01'is set,
  - 80:50:43:18:81:37 is a Unicast address – bit 0 of '80' is cleared
- Global/Local bit: 1 → Locally Administered, 0 → Globally Unique
  - If '1' it means the Address is Locally Administered and may not be globally unique
  - Duplicate MAC addresses are VERY bad for switches, thus these are rarely used

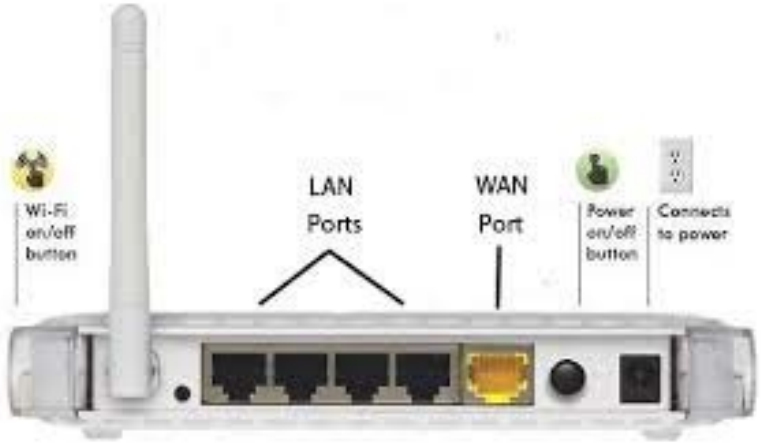
Is This An Automotive Problem?

- Sure.
- When IEEE runs out of MAC Addresses (in about a 100 years, today's guess) *ALL* users of MAC Addresses will suffer
- But don't panic!

- The IEEE RAC (Registration Authority Committee) has been working on this issue for the last couple of years
  - The purchase size options & use of MAC Addresses have been re-worked to support more efficient and more complete usage of MAC Addresses
  - And new work is starting up to solve these larger Use Rate issues as new applications that use Ethernet (Automotive, Lighting, etc.) ramp up

Possible Solution

- Before IPv6, the IPv4 addressing problem was solved with routers – and this solutions was so good its still used
- You probably have a router in your home
  - Its in the device used to connect your computers to the internet
  - Your home uses only one unique IP address to connect the 'outside' world
  - Each of your devices 'inside' your home get their IP addresses assigned – either automatically or statically such that they are locally unique
  - Your neighbor could be using the same IP addresses as your devices, but they don't 'see' each other due to the router
  - You can replace a computer and it automatically works!
  - Many routers support security!
  - These concepts port to MAC Addresses



The MAC Address's Global/Local Bit

- Systems (e.g., automotive, lawn sprinklers, building lights) that don't need all devices to have a 'direct' connection to the world's network can solve the problem in a similar way
- All they need is a 'Connection Device'
  - For Sprinklers this is likely the Sprinkler Controller
  - For Building Lights this is probably the Light Controller
  - For Automotive this could be the Head Unit or the Diagnostics Port Unit
- The Connection Device is the device that connects to the 'outside' world and uses a single Globally Unique Address
  - This device could automatically allocate Locally Administered MAC Addresses to all the 'inside' world devices – or –
  - Locally Administered MAC Addresses could be statically assigned as Message IDs are today for CAN bus implementations – or –
  - Some combination of above possibly with new IEEE protocols

What The Industry is Doing:

- The IEEE RAC has developed a Company ID (CID)
  - CID's are 24-bit, and are limited to a quadrant of Local Address space
  - CID's can identify a range of Local Addresses for a distribution protocol
- IEEE 802 started a new PAR (Project Authorization Request) to update the IEEE 802 Overview and Architecture on Local Addresses and CIDs
- These two actions will enable development of protocols for Local Address distribution
  - Any organization can develop a protocol and acquire a CID block for it
- IEEE 802.1 is also considering a PAR to define an address distribution protocol
- Lease instead of buy MAC Addresses?
- Raise the price of MAC Addresses?

What You Can Do:

- Educate your designers about this issue immediately
- Support the new work addressing these problems in the IEEE and other organizations like AVnu
- Adopt the new recommendations from these organizations for all new designs as soon as possible
- Use Globally Unique MAC Addresses only where a product connects to the 'outside' world:
  - For Automotive this could be no more than 4 per car – diagnostics port, Bluetooth, wireless cell and wireless WiFi
  - Use Locally Administered MAC Addresses for all the 'inside' world connections of a product
- The closed network in automotive allows for quicker adoption

Thank You!

We all have the responsibility to conserve our limited resources

End of “The Looming Ethernet MAC Address Crisis” presentation

In less an a week 2 auto makers confirmed to me that they will use this approach!

What Can IEEE 802.1 Do?

- The new PARs in IEEE 802 and IEEE 802.1 are a start
- But we need more than just an address distribution protocol for Locally Administered Addresses
  - This helps the new “closed” networks only (automotive & industrial)
- We need to conserve Globally Unique Addresses too!
- So what is a problem on IEEE 802.1’s side?
- Requiring unique addresses per switch port for IEEE 802.1 protocol frames causes Bridges to consume lots of MAC addresses
- With the vision of low cost AVB Bridges everywhere, that will mean many 10’s of millions of more MAC address per **month** will be consumed!

IEEE 802.1 Protocol SA's

- The Standards currently require each switch port to have a unique MAC address for IEEE 802.1 protocols
- Why? Confusion about proper MAC address usage from the 1980's? The unique MAC address per port solution was perfectly fine in that timeframe. Rates were low.
- Today, we have to do better! Or we are doomed…
- These frames don't use the Bridge Relay function so the Relay does not need to learn the SA's from these frames
  - So they don't need to be unique!
- If the CPU in a Bridge only does IEEE 802.1 protocols why does it need a Globally Unique MAC address anyway?
  - Think Plug-and-Play consumer AVB Bridges everywhere in the home – in the TV, Set Top Box, etc.

IEEE 802.1 Easier Solutions

- Allow AVB/TSN Bridges to use a specific SA address for the IEEE 802.1 protocols
  - Could be all zeros (Globally Unique) or all zeros (Locally Administered) or …
  - This can easily be specified as an Addendum to IEEE 802.1BA
  - This at least solves this problem for the new product areas
- Allow AVB/TSN Bridges to use only one Globally Unique address for the ‘end-node’ communications to the CPU
  - This is needed if the Bridge CPU needs to be exposed for MIB control
  - Now its only one address per Bridge – not ‘N’
  - Set-Top Boxes and TV’s still only need the one MAC address they would have already used for their ‘end-node’ function
- Will need to clearly specify MAC address learning rules for SA’s in IEEE 802.1 protocol frames
- Can this group solve this problem beyond just AVB/TSN?

IEEE 802.1 Harder Solutions

- Increase the Layer 2 MAC Address Size?
- Problem solved – but now everybody needs new Hardware!
- If we need to do this, then **NOW** is the time to get started
- And if we do this right, such that these new Layer 2 Bridges work with today's Layer 2 Bridges, then eventually all bridges will be 'new' (in 10 years or so) and the larger MAC address can be 'turned on' and used.
- Other benefits can come from this 'Extended Layer 2'
- One thing is for sure:
- **No hardware solution will be put into bridges for this unless there is an IEEE 802.1 Standard for it!**

Extended Layer 2 Proposal

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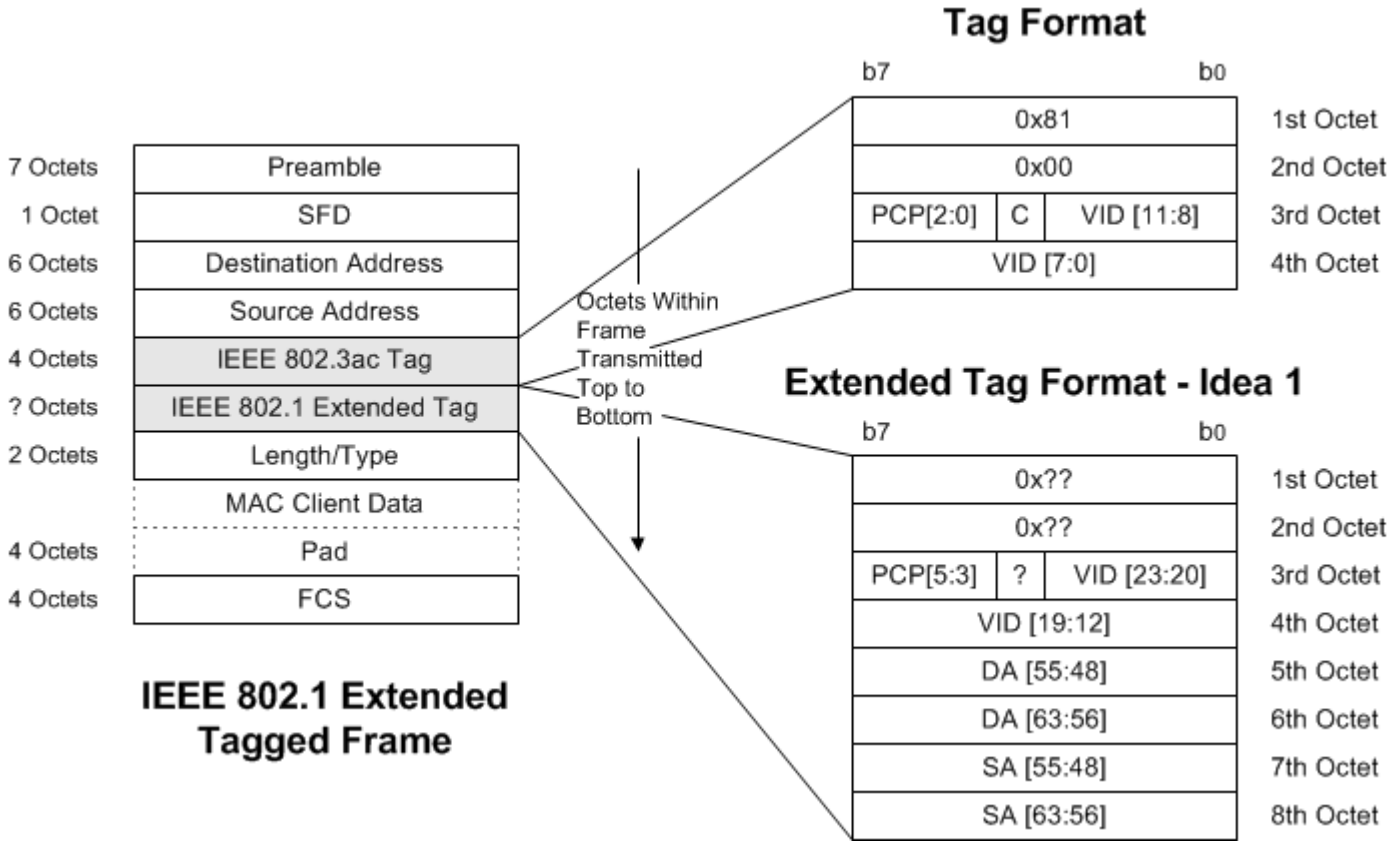
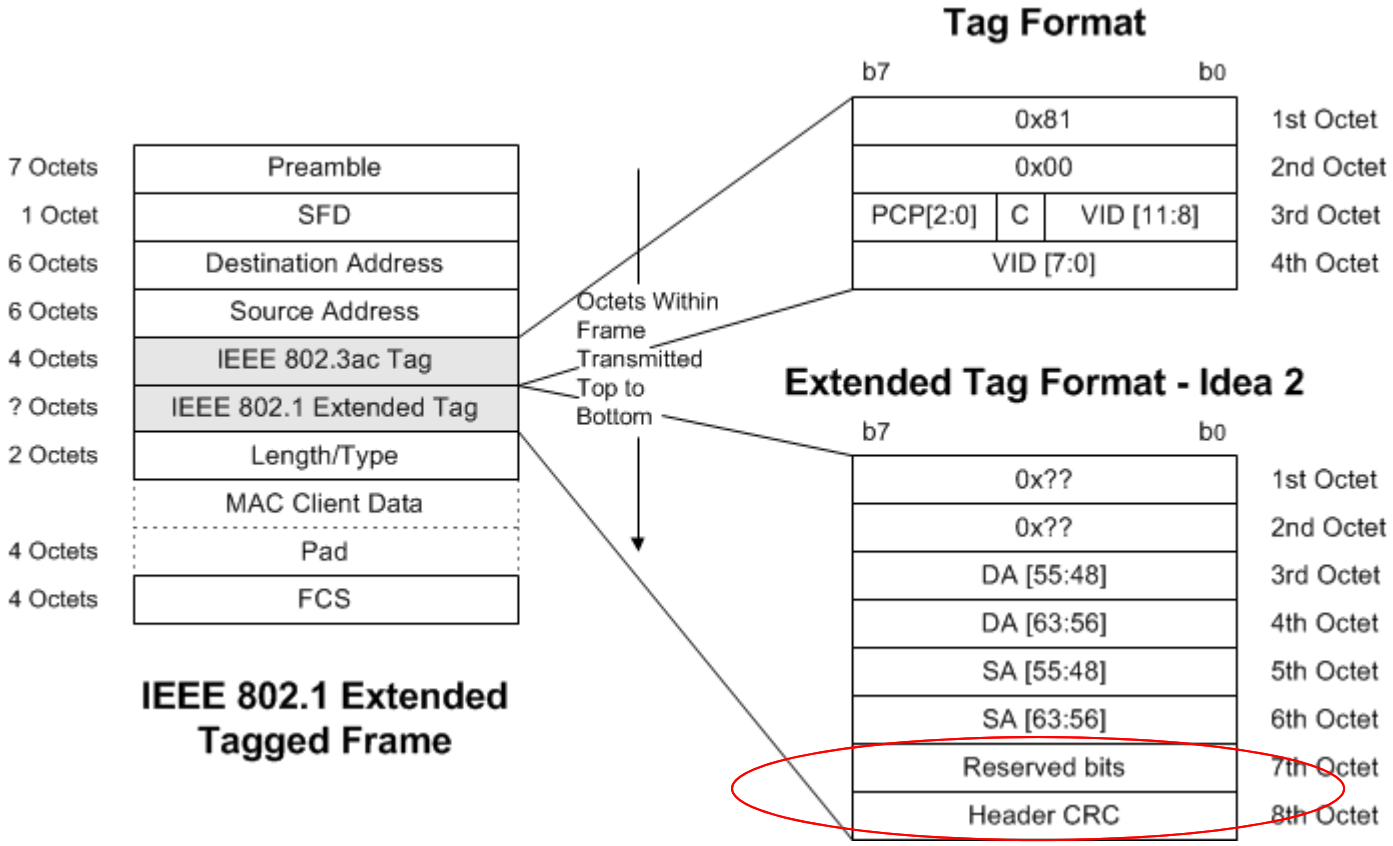
What Might this Look Like?



- This Extended Tag supports 64-bit MAC Addresses with 6 PCP bits & 24 VID bits
- Today's Layer 2 Bridges work 'as-is' w/these extensions when they are in the frame
  - As long as the lower 48-bit MAC addresses are unique & only 3 PCPs & 12 VIDs are used locally
- Modulo 4-byte Tags keep the MAC Client Data on the same 32-bit boundaries

Another Idea…



- This Extended Tag supports 64-bit MAC Addresses w/8 RSVD bits & Header CRC
- The Header CRC includes the Length/Type field & supports forwarding of frames with a good Header but with a CRC error in the MAC Client Data part of the frame
- This supports applications like video where its better to get most of the data even if some of the bits in the frame are in error

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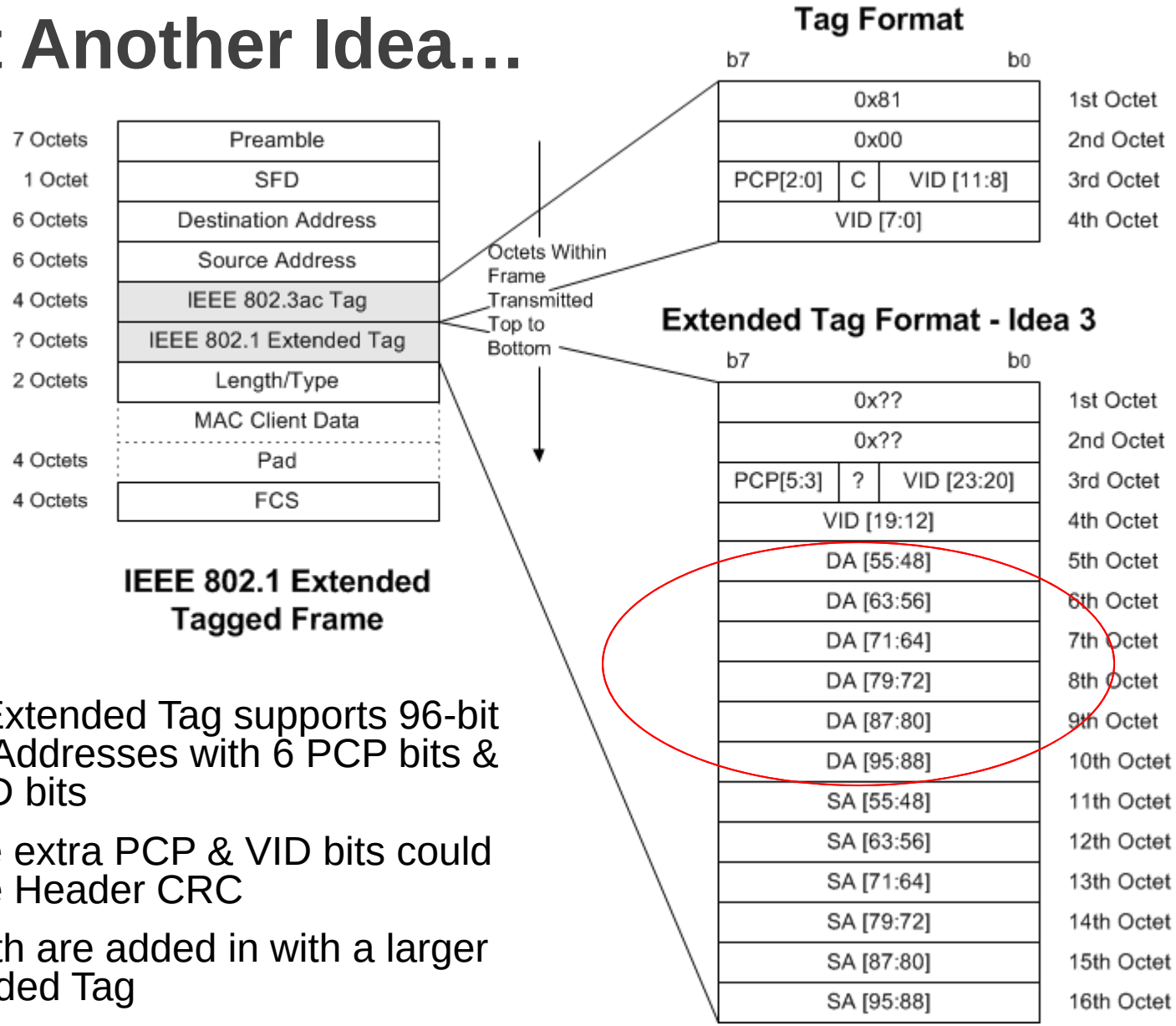
Yet Another Idea…



- This Extended Tag supports 96-bit MAC Addresses with 6 PCP bits & 24 VID bits
- Or the extra PCP & VID bits could be the Header CRC
- Or both are added in with a larger Extended Tag

You Get the Idea

- We have a problem – the ever increasing MAC Address usage rate – and it needs to be solved
- The solutions must come from all directions – not just new applications
- And IEEE 802.1 has to do our part too
- My goals for this presentation are the same as it was when I presented this information at the Ethernet & IP Tech Day:

- **1st to Educate everyone about this issue**
- **2nd Present some possible solutions, and**
- **3rd get people Involved in helping solve the issue**

Thank You!

MAC Address

We all have the responsibility to conserve our limited resources

So what ideas do you have that might help?