802.11 Station Bridges

Three solutions to the problem of 802.11 stations that are also bridges

Rev. 2

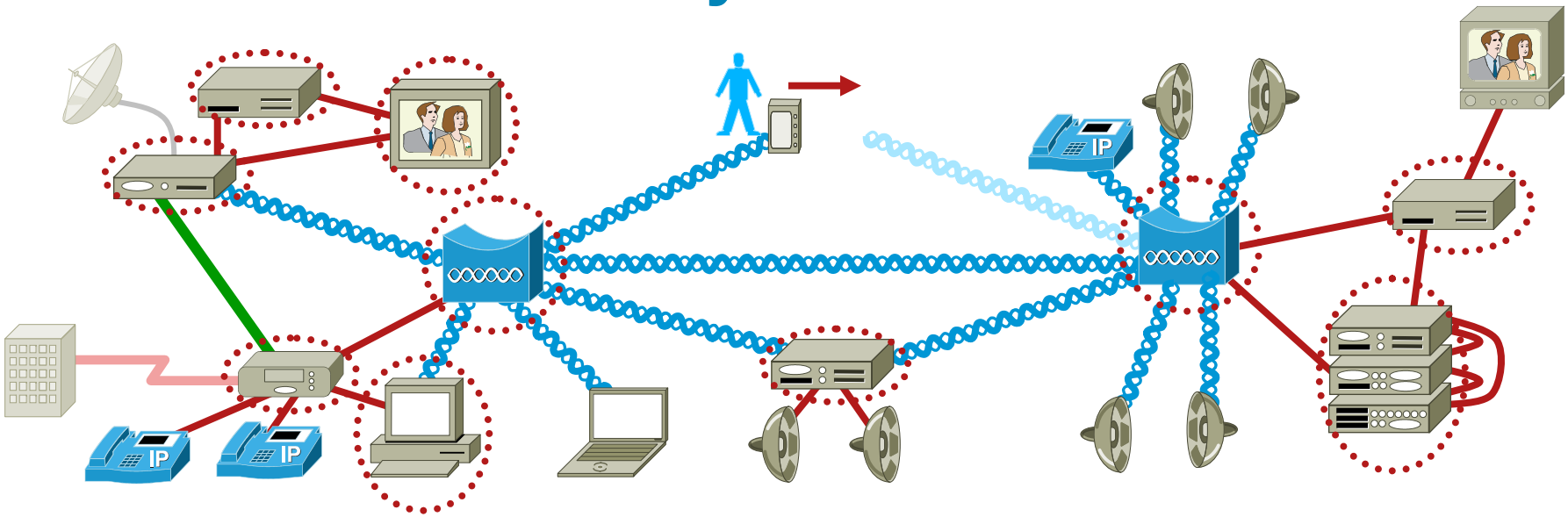
Norman Finn

nfinn@cisco.com

References

- This presentation is available at: http://www.ieee802.org/1/files/public/docs2008/avb-nfinn-802-11-bridging-0308-v2.pdf
- For a more complete description of the 802.11 station bridge problem, see: http://www.ieee802.org/1/files/public/docs2007/avb-nfinn-wireless-bridges-0707-v2.pdf

Executive summary



- In a home or small studio, there may be many Ethernet-like links: 802.3, 802.11, MoCA, Ether/DSL, etc.
- To ensure connectivity, every device with multiple links must be an 802.1 bridge, whether M/RSTP or 802.1aq.
- The IEEE 802 standards do not support an 802.11 wireless “station” that is also a bridge.

The core of the problem

- IEEE Std. 802 leaves it up to a particular medium whether frames transmitted on that medium are reflected back and received at the source.
- IEEE Std. 802.1D and 802.1Q make it clear that a bridge does not work on any medium that reflects frames back to the source.
- Most implementations of IEEE 802.11 wireless stations reflect frames back to the source.
- There are (at least) three potential solutions to this problem.

Terminology

Terminology

- The term, “station” has a meaning in IEEE 802.11 standards that differs from its meaning in common usage.

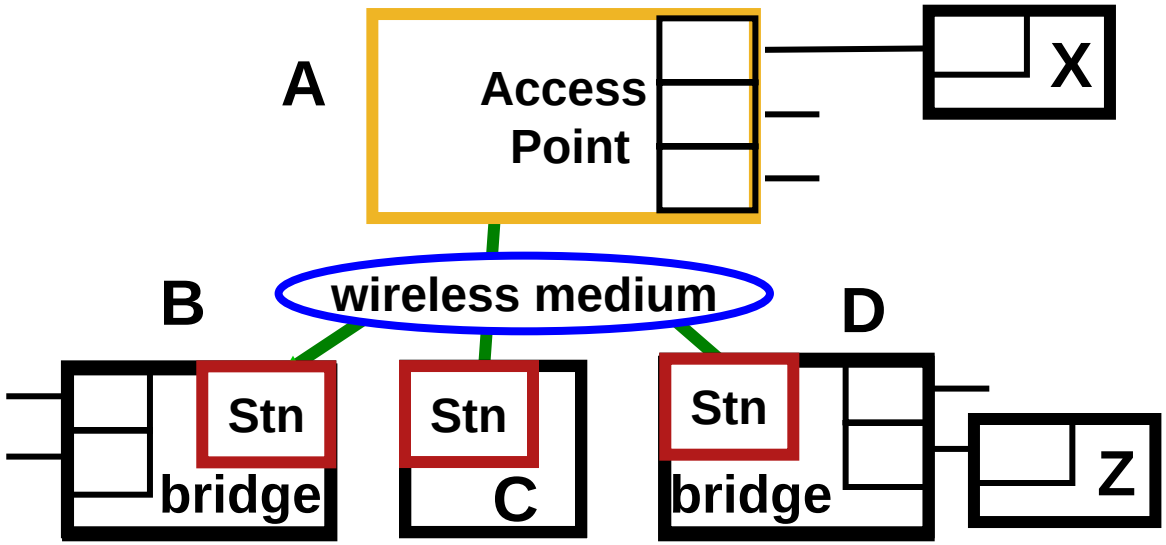
  Every MAC that is attached to a wireless medium is a station.

  One station in a typical wireless network operating in infrastructure mode is an access point station, or AP station.

  Thus, there are “AP stations” and “non-AP stations.

- Furthermore, the only clients of these stations are the “distribution system”. This is an entity that is distributed over all of the stations of all of a set of interconnected wireless media.
- The points at which PCs or bridges access the distribution system are called “portals”.

802.11 terminology: incorrect

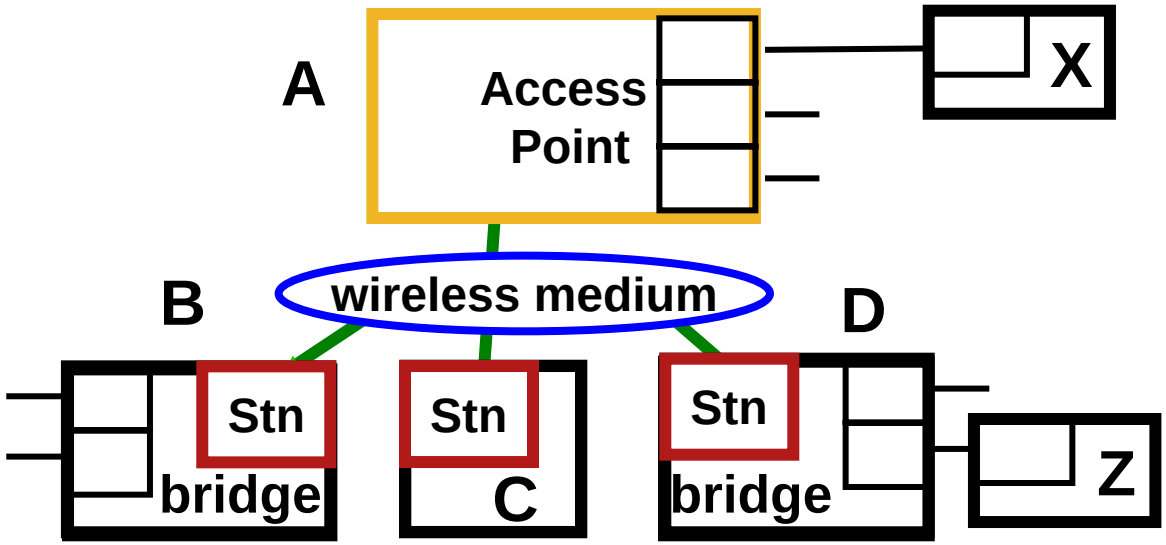


- This is how the terminology is, incorrectly but commonly, used:

  The access point is the thing at the top.

  The stations are interfaces stuck in the things at the bottom

802.11 terminology: incorrect

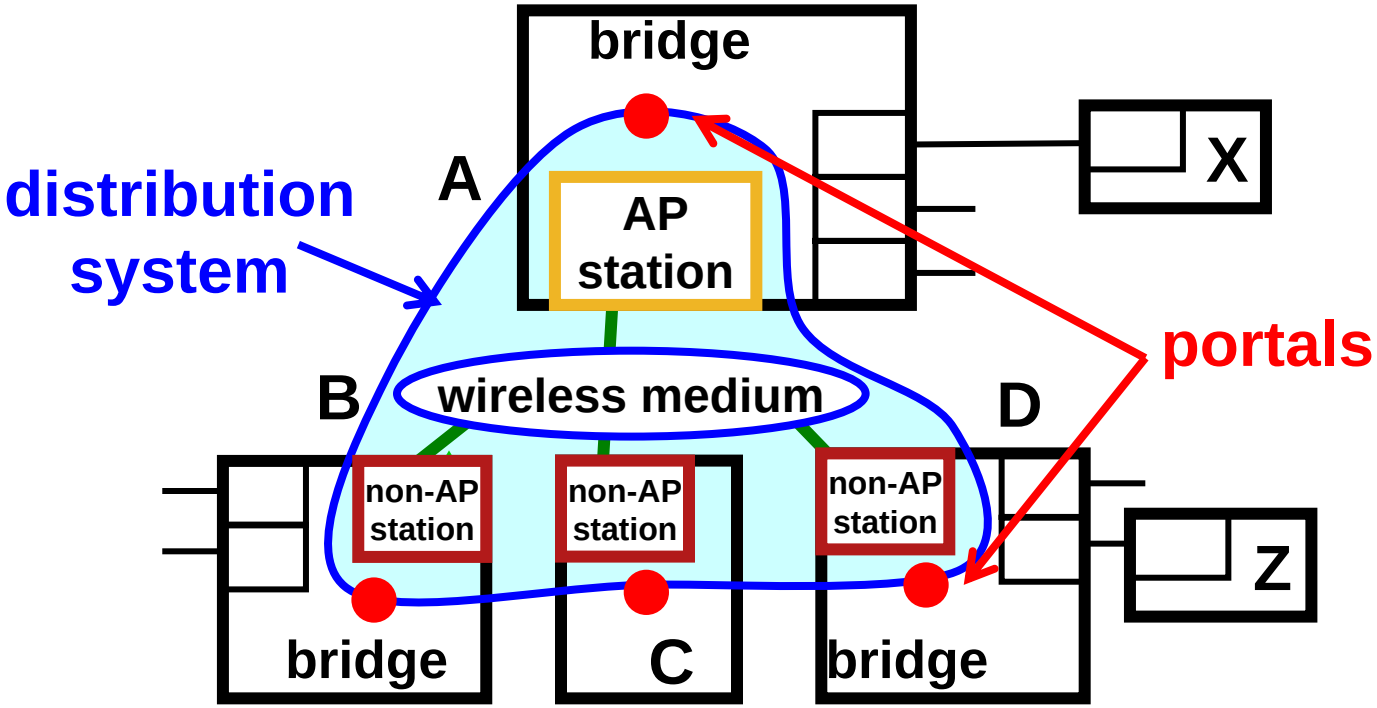


- This is how the terminology is, incorrectly but commonly, used:

  The access point is the thing at the top.

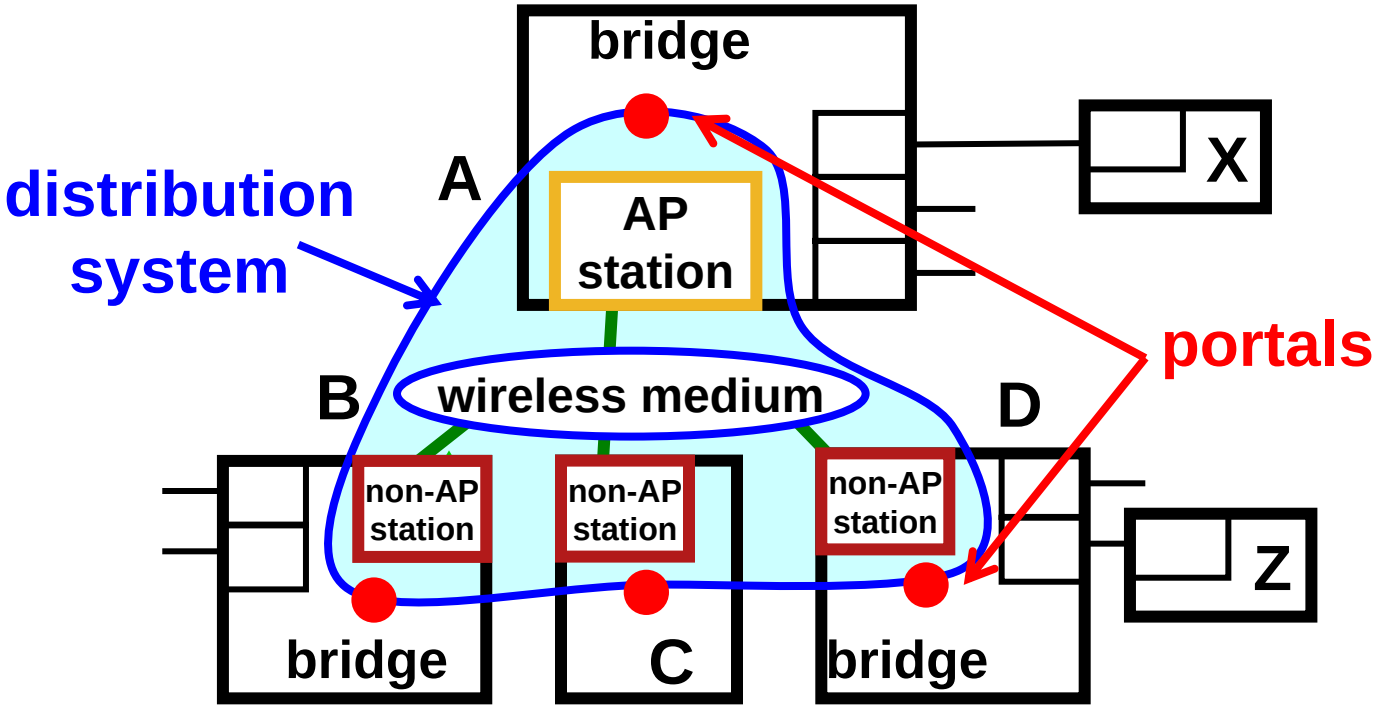
  The stations are interfaces stuck in the things at the bottom

802.11 terminology: (almost) Proper



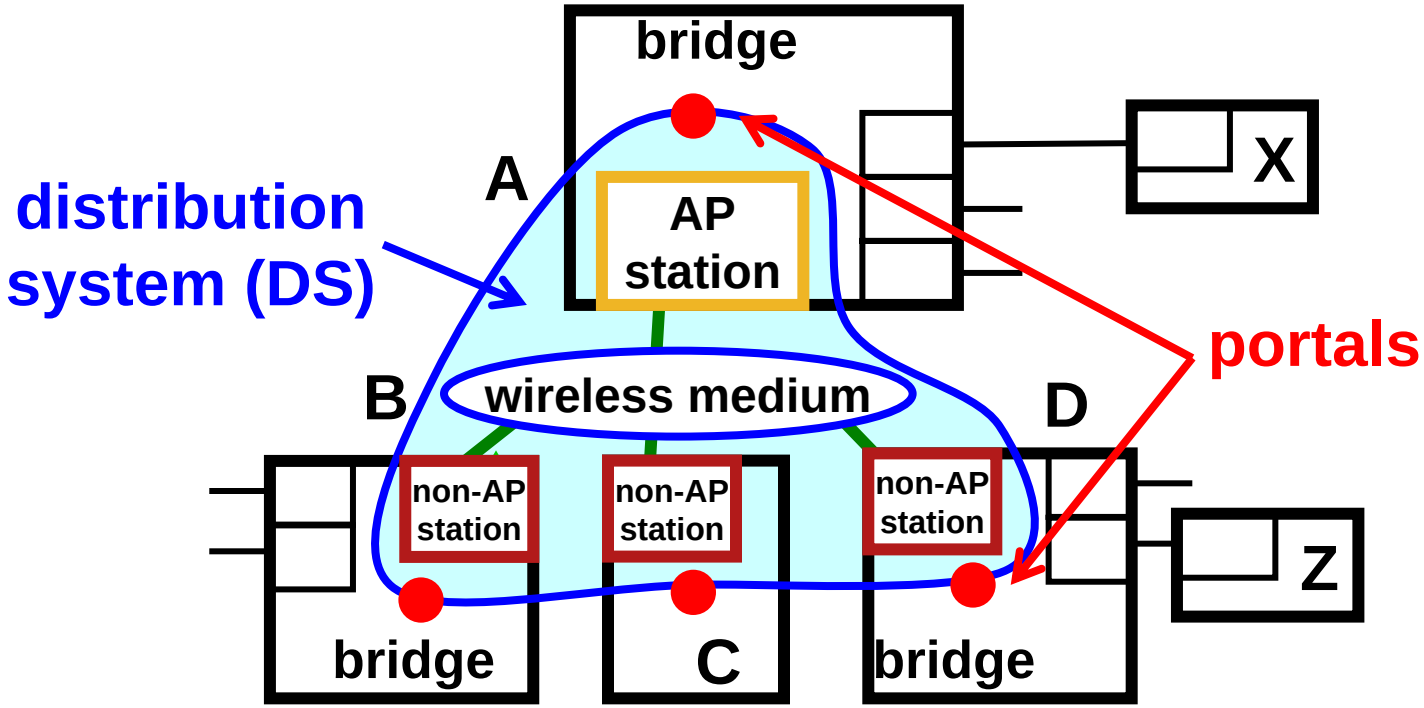
- More properly, the wireless medium is simply one of potentially many LANs connecting the stations, AP and non-AP, that support the distribution system (DS).
- Access to the distribution system is through portals.
- This ignores the restriction that a portal can only be co-located with an AP station.

802.11 terminology: Proper



- Among the requirements placed on a portal is the requirement that, if a multicast or broadcast is passed into the DS through a portal, it is passed to all of the other portals, but not back out the ingress portal.

802.11 terminology: The bad news



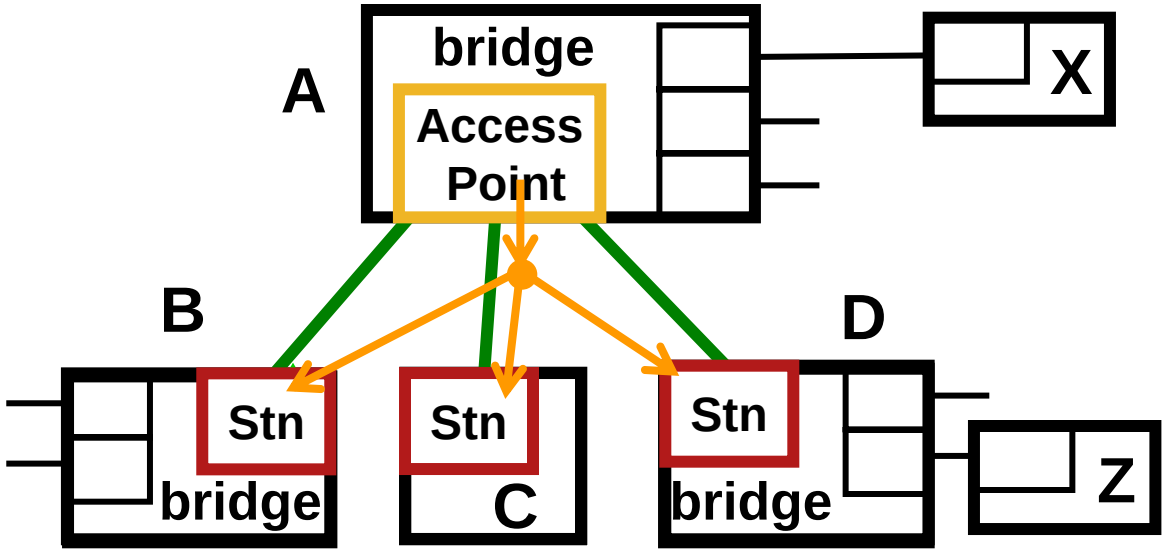
- Unfortunately:

  "Station" and "access point" vendors do not, in general, supply proper portals.

  There is no interoperable standard definition for the information exchange among the stations of a DS that is required to actually implement the "no reflection" rule.

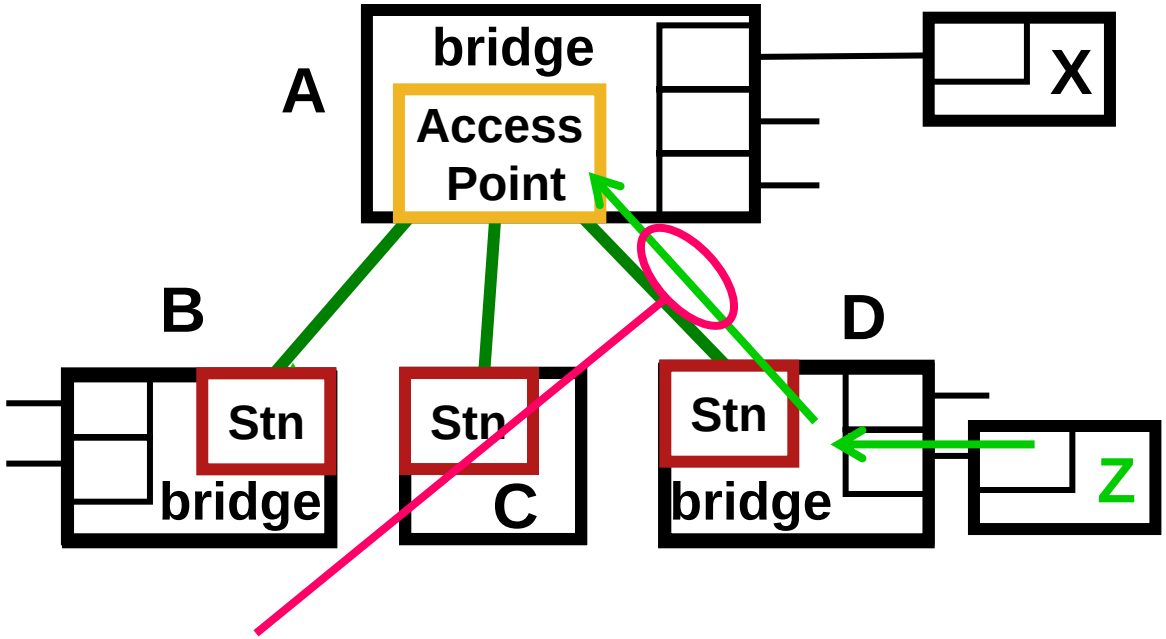
Solution 1: Four address format

Wrong terminology for a moment



- Let us, just for a moment, use the incorrect but commonly used terms for “station” and “access point”, but separate the AP from the bridge in which it is embedded.

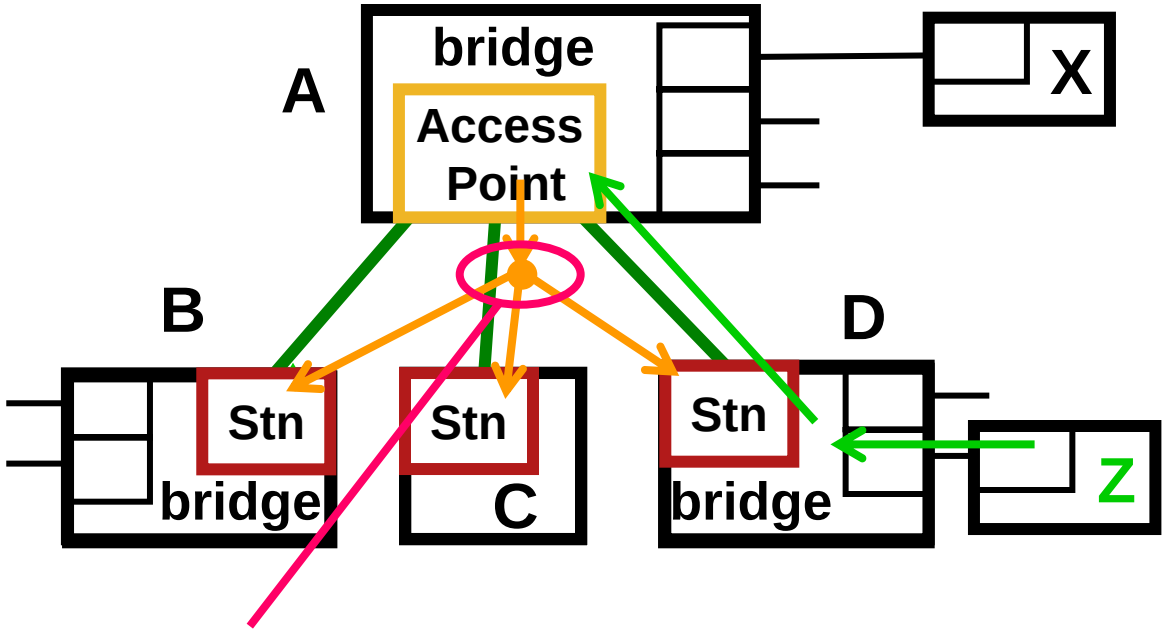
Four address format



- In the UP direction, use the 802.11 four-address format:

Receiver Address:	A, the access point
Transmitter Address:	D, the transmitting station
Destination Address:	Original Ethernet destination
Source Address:	Z, the Ethernet source

Four address format



- In the DOWN direction, use the four-address format:

Receiver Address:	Multicast address indicating, “not D”
Transmitter Address:	A, the access point
Destination Address:	Original Ethernet destination
Source Address:	Z, the Ethernet source.

Special multicast address: “Not XYZ”

- We need a Receiver Address in the DOWN (reflected) frame such that the station that transmitted the frame to the access point, in this case Bridge D, will discard the reflected frame, and all other stations will accept it.
- Using D’s MAC address (the Transmitter Address from the UP frame) would accomplish this, but that would be a perversion of the meaning of the Receiver Address – “everybody except this unicast address should receive the frame”.
- Instead, we can use a fixed range of multicast MAC addresses, taken from an 802.1 or 802.11 OUI, and place the Association Identifier of a station in the low-order bits of the address.

Special multicast address: “Not XYZ”

- Each station subscribes to (accepts) all of these multicast addresses except the one with its own AID, thus accomplishing the suppression of own-multicasts.
- This is perfectly normal behavior for dealing with multicast addresses, and is compatible with the spirit of the definitions of the four addresses.
- For broadcasts or multicasts coming from the bridge / access point, rather than being reflected from a station’s transmission, the Receiver Address can be either:

  A special AID value, indicating the access point.

  The broadcast address.

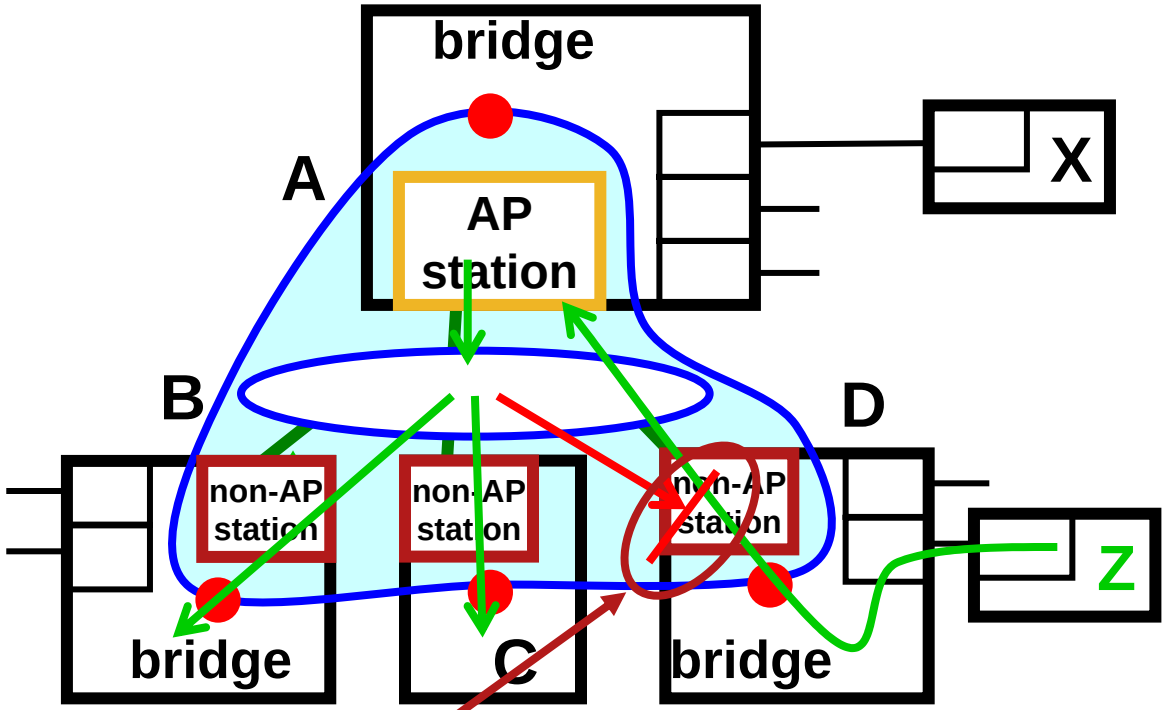
- This solution applies to 802.1aq, as well as 802.1Q.

Compatibility with old Stations

- The access point must be 4-address capable.
- All data frames transmitted or received by Station Bridges are in 4-address format.
- 4-address-capable Stations operate either in 3-address or in 4-address mode, but not both, and the access point knows which.
- Station Bridges and 4-address-mode Stations ignore 3-address frames.
- Old 3-address-only Stations (hopefully) ignore 4-address frames.
- If a frame, e.g. a broadcast, needs to be sent to both 4-address and 3-address Stations, then the access point must send two copies, one in each format.

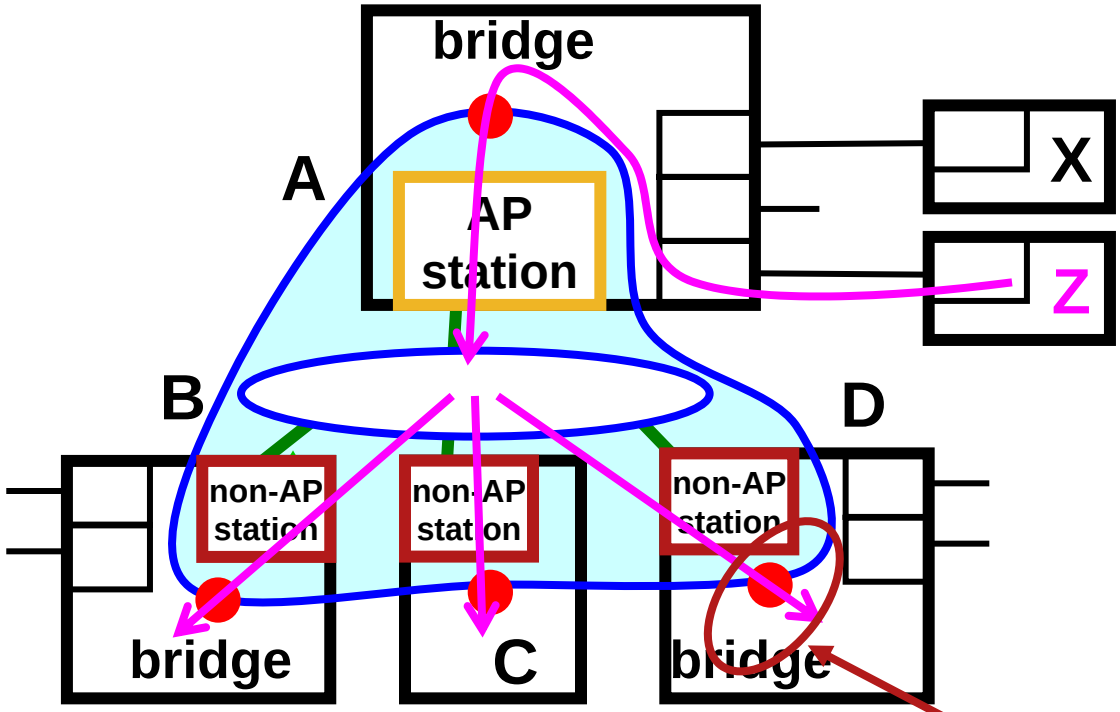
Solution 1 recast into proper terminology

Trivial DS protocol



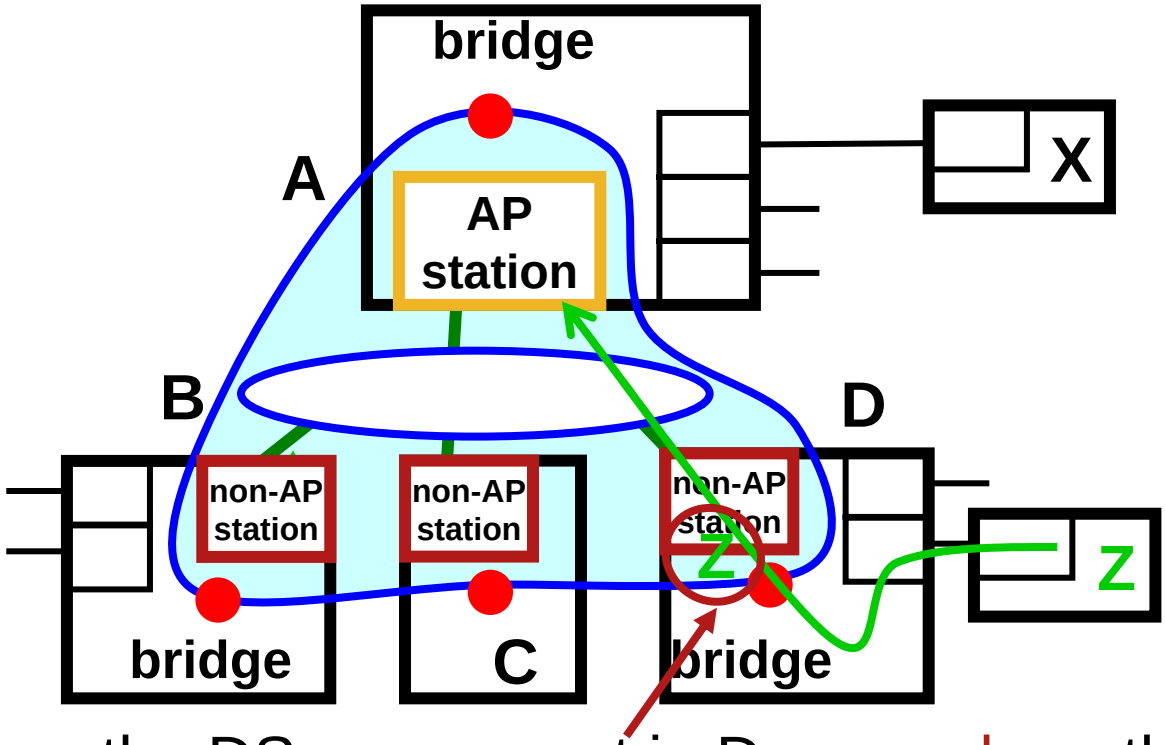
- What might prevent the portal in D from returning a reflected broadcast from Z?
- The easiest way is for the DS component in D to remember that address Z entered the DS through D's portal.

Trivial DS protocol



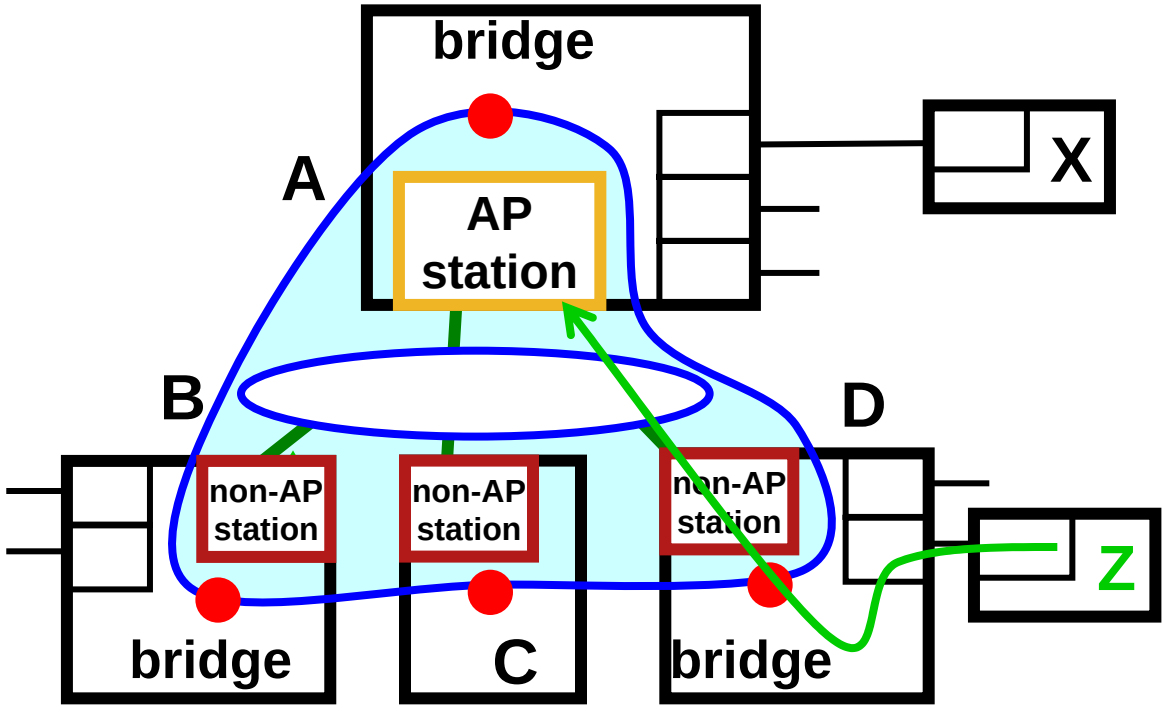
- But, if Z moves elsewhere and sends another broadcast, how will the DS component in D know to pass it through the portal?

Trivial DS protocol



- Answer: the DS component in D remembers that Z is a local address.
- It also signals the DS component in the AP station that address Z “belongs” to the portal in D.

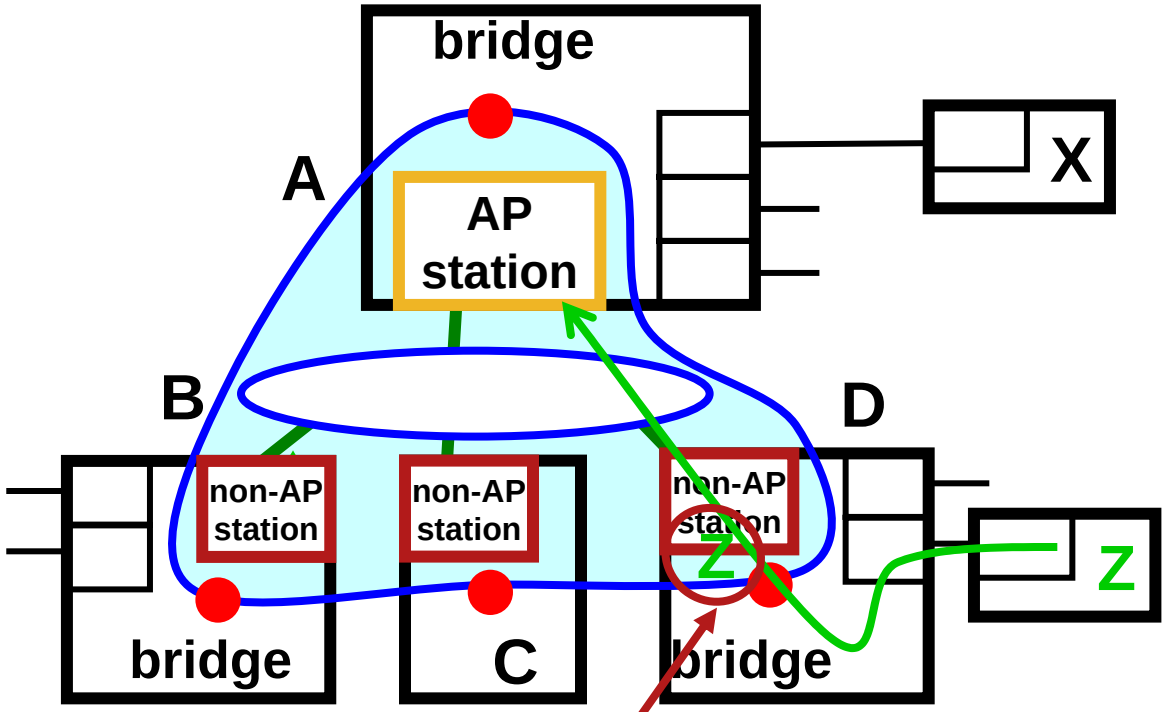
Trivial DS protocol



- The 802.11 four-address format can be used to signal ownership:

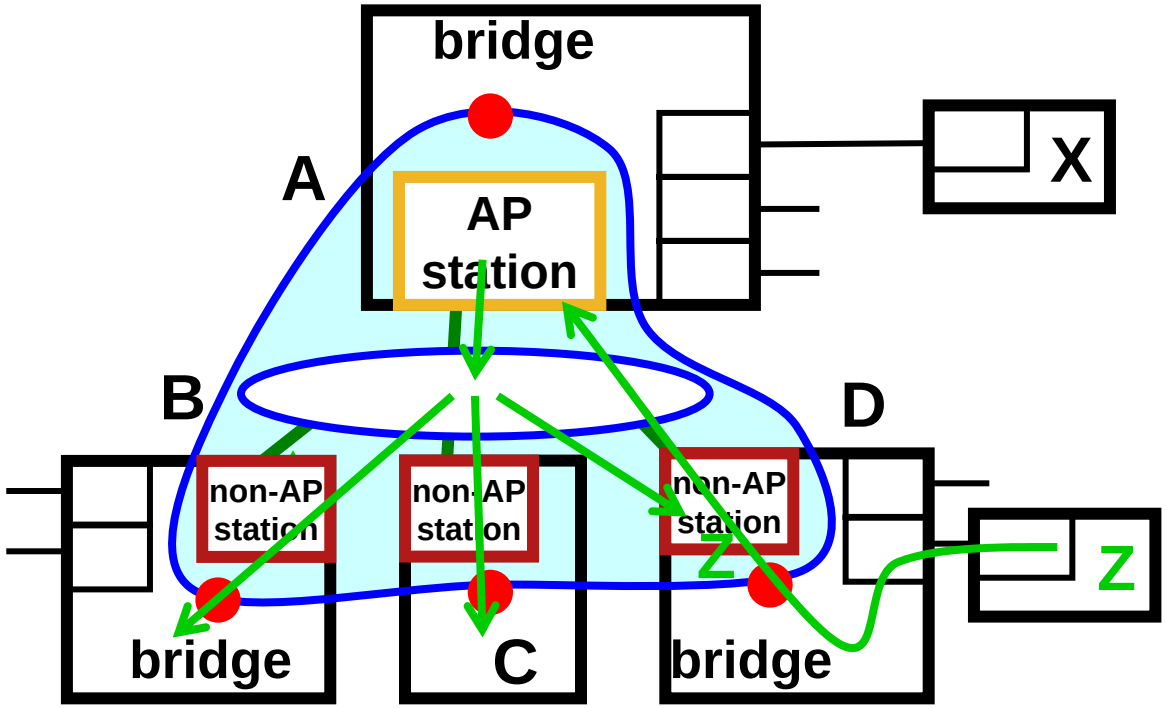
Receiver Address:	A, the access point
Transmitter Address:	D, the transmitting station
Destination Address:	Original Ethernet destination
Source Address:	Z, the Ethernet source

Trivial DS protocol



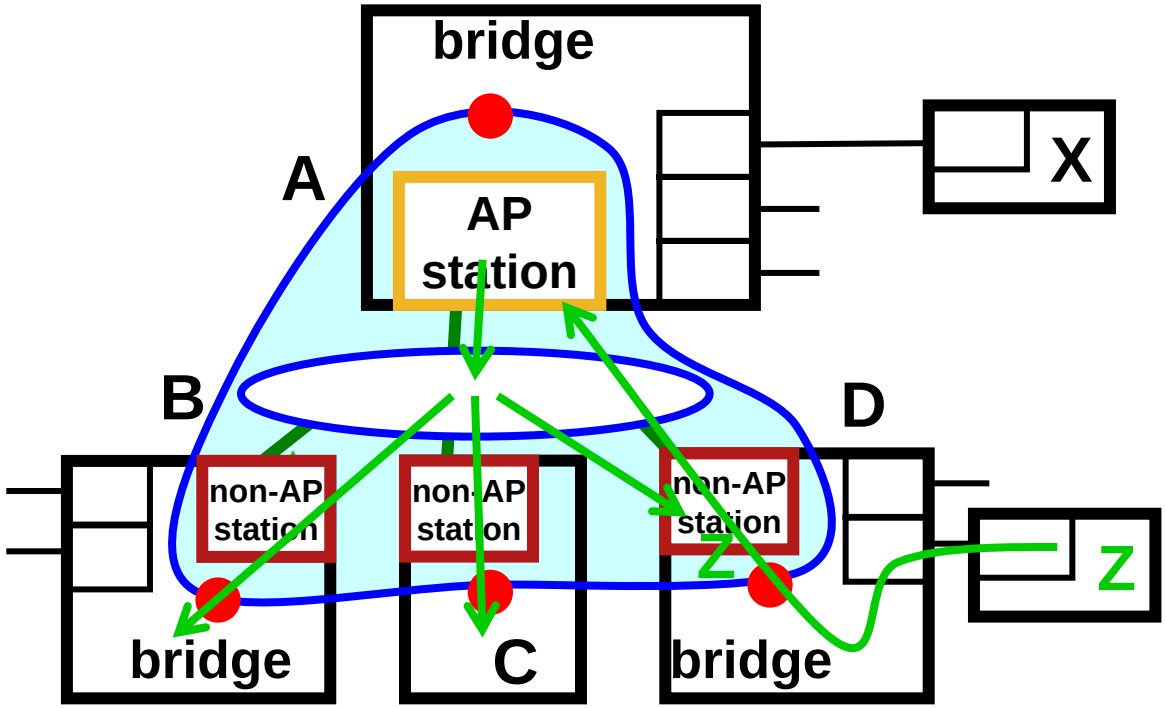
- The DS component in D remembers that Z is a local address.
- It signals the AP stn DS component, via the 4th address, that it (non-AP stn D) owns address Z.
- The actual frame is piggybacked on the ownership signal.

Trivial DS protocol



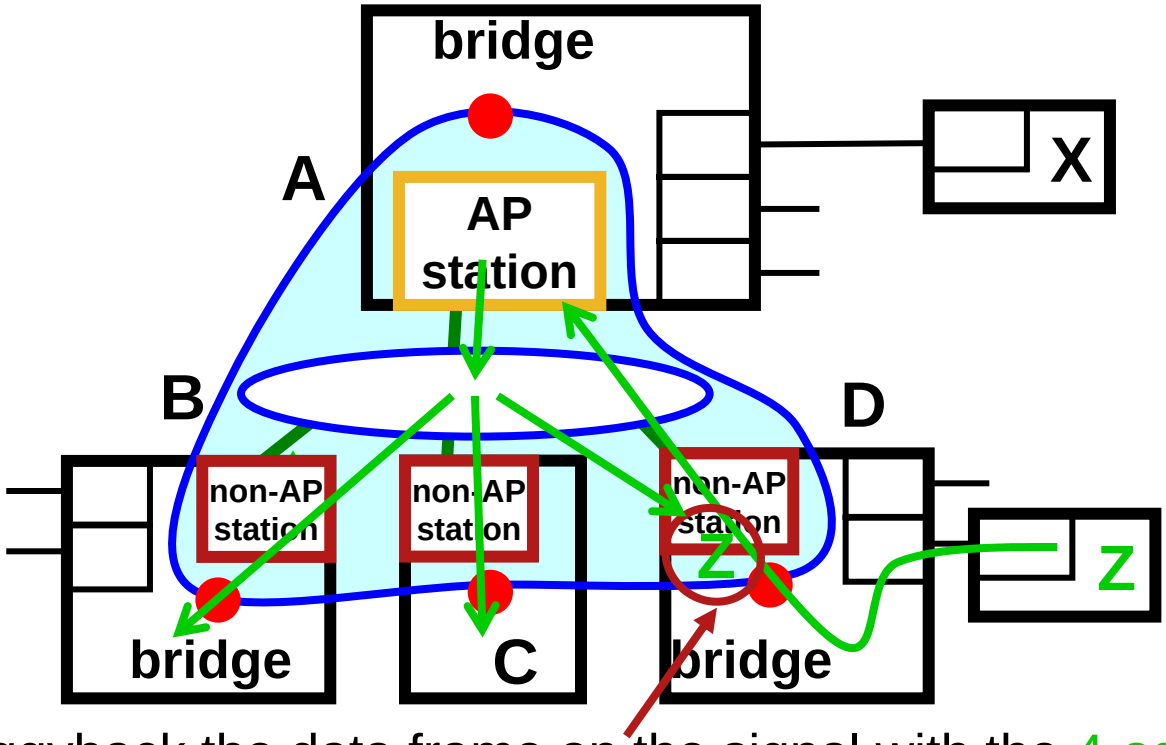
- To all DS components except the one in D, address Z belongs to the DS component in A, not to D, because they cannot reach D except through A.
- But, the other DS components don't care that A owns it; they just need to know what addresses they own..

Trivial DS protocol



- So, DS component A needs to tell all of the other DS components that it owns address Z,
- Except, DS component A must not tell the DS component in D that it owns Z; D still owns Z, and A knows it.

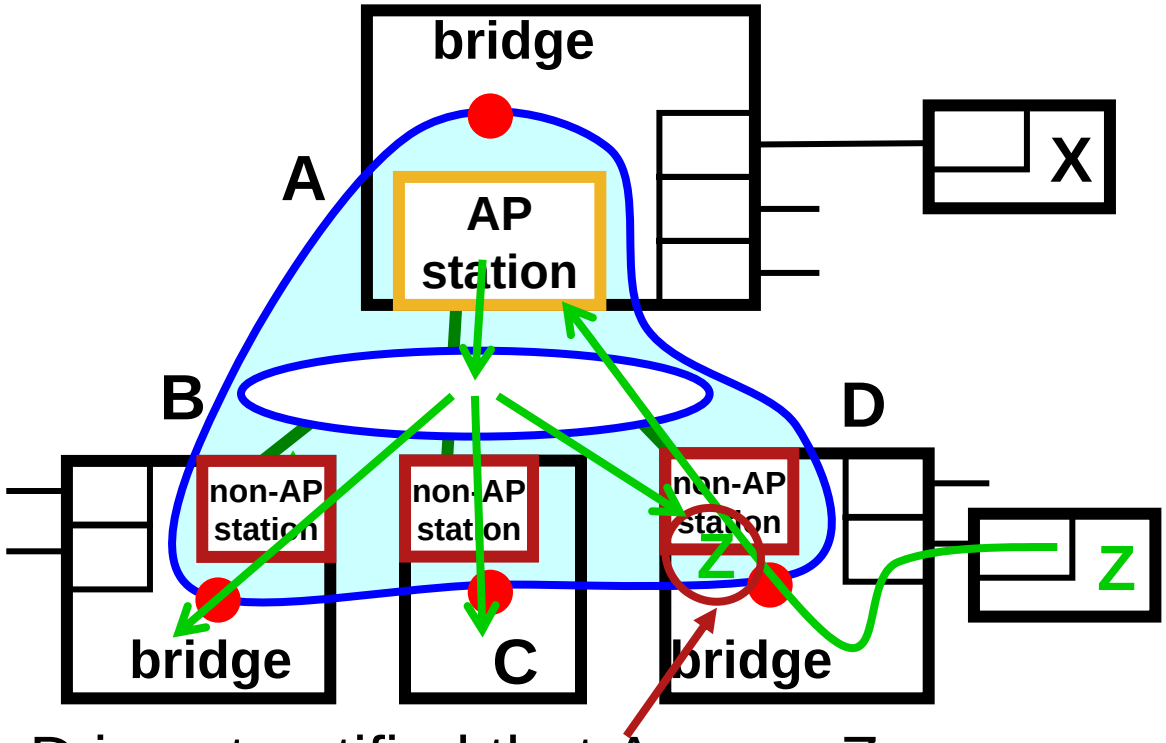
Trivial DS protocol



- We piggyback the data frame on the signal with the 4-address format:

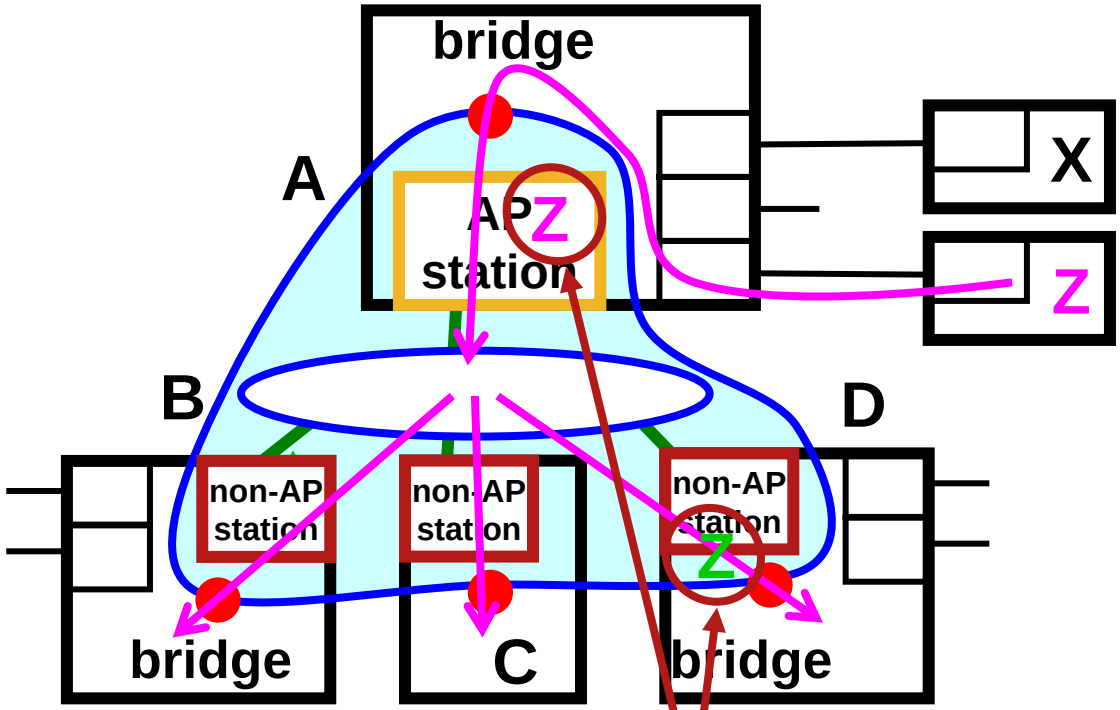
Receiver Address:	Multicast address, “everybody except D”
Transmitter Address:	A, the access point
Destination Address:	Original Ethernet destination
Source Address:	Z, the Ethernet source.

Trivial DS protocol



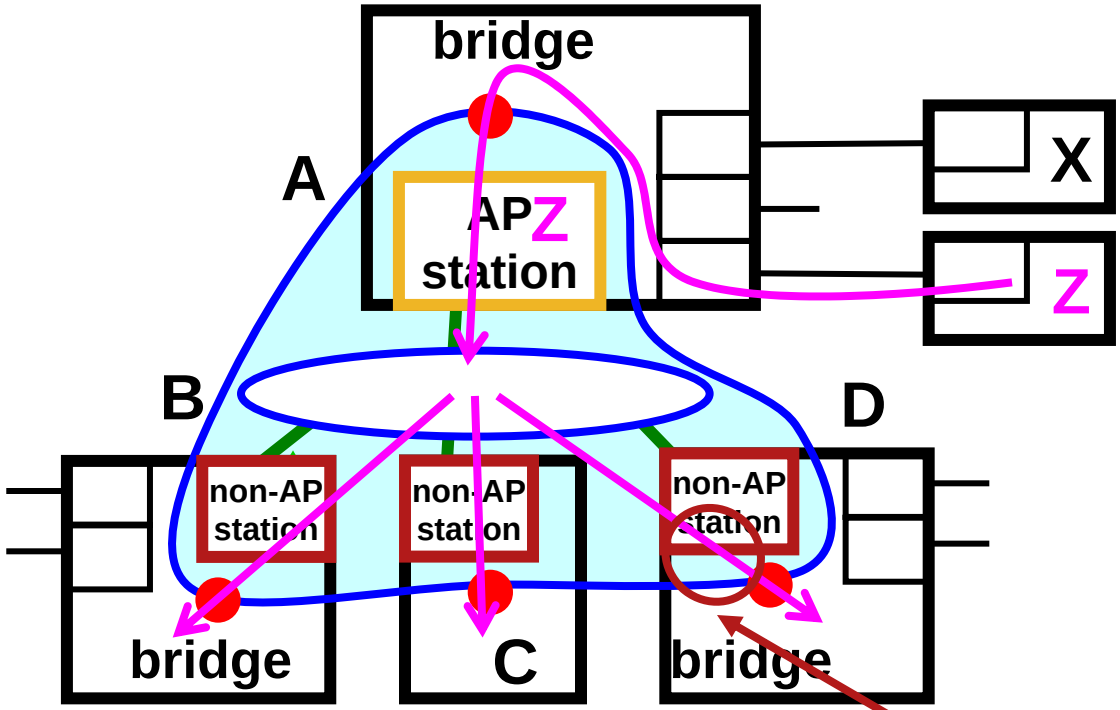
- Thus, D is not notified that A owns Z.
- The other DS components hear that A owns Z, but ignore the information, and pass the frame through their portals.
- D does not pass the data through its portal.

Trivial DS protocol



- When Z moves elsewhere and sends another broadcast, the A must notify all of the other DS components that A, instead of D, now “owns” address Z.
- This signaling must be done before the data frame is sent, so that the broadcast will not be discarded in D.

Trivial DS protocol



- The four-address format to signal ownership of Z

Receiver Address:	Broadcast address: everyone forgets Z!
Transmitter Address:	A, the access point
Destination Address:	Original Ethernet destination
Source Address:	Z, the Ethernet source.

Trivial DS protocol

- Every non-AP station remembers what addresses it owns.
- Every AP station also remembers the addresses it owns, and may remember which addresses are owned by each of its attached non-AP stations.
- Address ownership (other than the address of the station, itself) is learned only by:

  Receiving data requests through a portal; or by

  Receiving ownership signals from other stations.
- Addresses learned from a portal are remembered until the station is reset; addresses learned from a signal are remembered until the signal source is dis-associated.

Trivial DS protocol

- Whenever a data request enters a portal, the station remembers that it owns that source address, and signals ownership:

  To its attached AP stations, if the owner and transmitter is a non-AP station;

  To at least those AP stations that should receive the data request, if the owner and transmitter is an AP station; or

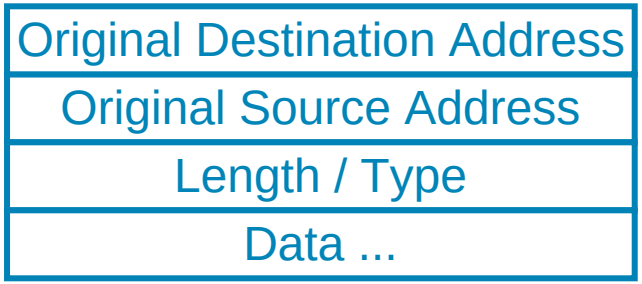
  To at least those AP stations that should receive the data request, but never the owner AP station, if the owner is an AP station and the transmitter is a non-AP station.

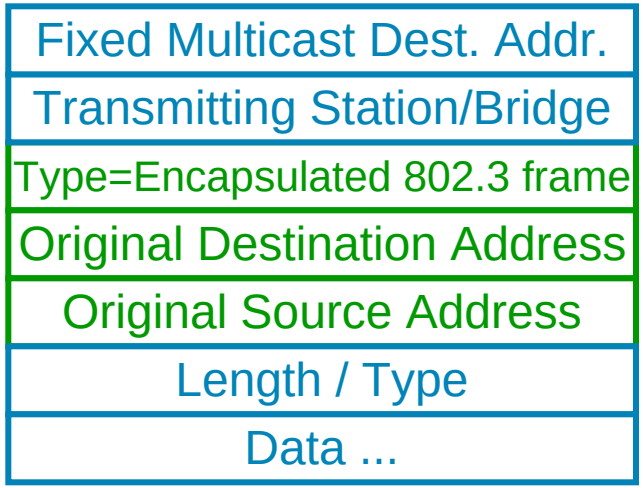
- Ownership of addresses is signaled only by piggybacking the ownership signal on a data frame, using the four-address format.

  The DS component identified by the transmitter address claims ownership of the source address.

Solution 2: Encapsulated 802.3 EtherType

Encapsulated 802.3 EtherType





Original **Encapsulated**

- Extra transmitter/receiver address not shown.
- We define a new EtherType, meaning “An 802.3 frame follows.”
- The extra addresses allow reflection suppression.

Encapsulated 802.3 EtherType

- The access point still has to change, as for the 4-address solution. (These encapsulated frames cannot be passed on to the wired network behind the access point.)
- All of the encapsulated vs. unencapsulated rules apply exactly as for 3-address or 4-address rules for the 4-address solution.
- This solution would be available for other reflective media, should any become common.
- This solution is a valid alternative, if there are large numbers of stations that would cause the 4-address solution to fail.
- This solution applies to 802.1aq, as well as 802.1Q.

Summary

Summary

- The 4-address and Encapsulation solutions can be quickly available.
- Ranked by frame size penalty, least to greatest:

  4-address (with STP or with 802.1aq)

  Encapsulation (with STP or with 802.1aq)

Summary

- In all three solutions, the access point has to change; the stations and bridges cannot do it alone.
- In all three solutions, a mixture of new station bridges and old stations that don't know the new technique requires broadcasts to be sent twice.
- Only the four-address format solution and the mesh networks solution are compatible with the 802.11 architecture.
- The four-address solution seems vastly simpler and more amenable to quick implementation than the mesh networks solution.


CISCO