IEEE 802 Address Assignment with P802.1CQ

IETF 112, intarea
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not the formal position, explanation, or interpretation of the IEEE
but rather the personal views of:

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P802.1CQ Status [1]

- IEEE SA Project Authorization (PAR) P802.1CQ
  - Initiated: 2016-02-05; Extended 2020-06-03; Expires: 2022-12-31
- *Draft Standard for Local and Metropolitan Area Networks: Multicast and Local Address Assignment*
  - IEEE 802 addresses (MAC addresses)
- In 802.1 Working Group, Time-Sensitive Networking (TSN) Task Group
  - https://1.ieee802.org/tsn/802-1cq/
- Current draft: P802.1CQ/D0.7
  - reviewed in Task Group Ballot
  - comment resolution completed in September
- Awaiting editor's implementation of new draft
  - IETF/802 coordination meeting has indicated that it should be shared with intarea

P802.1CQ PAR Details

- **Scope**: This standard specifies protocols, procedures, and management objects for **locally-unique assignment** of 48-bit and 64-bit addresses in IEEE 802 networks. **Peer-to-peer address claiming and address server capabilities are specified**.
- **Need**: Currently, global addresses are assigned to most IEEE 802 end station and bridge ports. **Increasing use of virtual machines and Internet of Things (IoT) devices could exhaust the global address space**. To provide a usable alternative to global addresses for such devices, this project will define a set of **protocols that will allow ports to automatically obtain a locally-unique address in a range from a portion of the local address space**. **Multicast flows also need addresses to identify the flows**. They will benefit from a set of protocols to distribute multicast addresses. Peer-to-peer address claiming and address server capabilities will be included to serve the needs of smaller (e.g. home) and larger (e.g. industrial plants and building control) networks.

Multicast Address Assignment

- In P802.1CQ, multicast addresses are assigned to end stations.
  - In other scenarios, multicast addresses are assigned to protocols.
- In some TSN networks, streams are addressed to multicast addresses assigned by the sender (the “talker”).
- A peer-to-peer protocol (MAAP) for a talker to claim a multicast address range is specified in IEEE Std 1722 (Transport Protocol for Time-Sensitive Applications in Bridged LANs).
- P802.1CQ provides backward compatibility with MAAP.
  - new functionality:
    - address blocks
    - Registrars (address servers)
    - operation without a global address

Power of Dynamic Software-Defined Addressing

- Half of IEEE 802 addresses are global
  - unique among all devices over an intended span of 100 years
  - generally burned-in by the factory, so flat
- Half of IEEE 802 addresses are local
  - assignable dynamically
  - vast quantity available, since uniqueness restriction limited to the LAN
  - can be liberally assigned
  - can be thoughtfully assigned to have addressing power
- Block Address Registration and Claiming” (BARC) protocol

BARC assigns MAC Addresses in Blocks

- An Address Block (AB) is a set of local BARC addresses.
- An AB includes equal-sized and unicast and multicast contiguous sub-blocks.
- No BARC address falls within more than one AB.
- Registrable Address Block Identifier (RABI)
  - identifies a Registrable Address Block (RAB) holding Registrable Addresses (RAs)
  - RABIs are held in inventory of a Registrar
    - may be assigned to Claimants
- Claimable AB Address (CABA)
  - identifies Claimable Address Blocks (CABs) holding Claimable Addresses (CAs)
  - claimable by a Claimant without using a Registrar
  - CABA is a multicast MAC address, not in any AB, and used as a DA
- An Address Block Designation (ABD) is a CABA or a RABI.
- A large set of Temporary Unicast Addresses (TUAs) is specified
  - useful for initial discovery by Claimant lacking a unicast address

BARC MAC Address Structure

N0	r	i	j	k	for registrable addresses, r=1; for claimable addresses, r=0
N1	1	1	1	m	m is the usual multicast (I/G) bit; 111 for “SAI*” (Standard Assigned Identifier)
N2					0000 for CA or TUA
N3					
N4					
N5					
N6					
N7					
N8					
N9					
N10					
N11					

12 nibbles per 48-bit address

- address block includes subblocks of
  - 16^{jk} claimable addresses, or
  - 16^{jk} registrable addresses (or aggregated into larger blocks)
- for claimable addresses, *i* distinguishes
  - Claimable Addresses (CAs) from
  - CABAs
    - identifiers that are also used as addresses
- see P802.1CQ/D0.7 for details

*per IEEE Std 802 [2], “Specification of the use of the SAI quadrant for SLAP address assignments is reserved for the standard forthcoming from IEEE P802.1CQ”

64-bit CA,RA,TUA

N12
N13
N14
N15

	r	i	jk	m
CA	0	1	CAB Size	I/G
CABA	0	0		1
TUA	0	0	0	0
RA	1	RABI Option	BABI Size	I/G

CABA and CA, CAB Size 0-3

	CAB Size C=0		CAB Size C=1		CAB Size C=2		CAB Size C=3	
	CABA	CAB	CABA	CAB	CABA	CAB	CABA	CAB
N0	0 0 0 0	0 1 0 0	0 0 0 1	0 1 0 1	0 0 1 0	0 1 1 0	0 0 1 1	0 1 1 1
N1	1 1 1 1	1 1 1 *	1 1 1 1	1 1 1 *	1 1 1 1	1 1 1 *	1 1 1 1	1 1 1 *
N2	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
N3	X3	X3	X3	X3	X3	X3	X3	X3
N4	X4	X4	X4	X4	X4	X4	X4	X4
N5	X5	X5	X5	X5	X5	X5	X5	X5
N6	X6	X6	X6	X6	X6	X6	X6	X6
N7	X7	X7	X7	X7	X7	X7	X7	X7
N8	X8	X8	X8	X8	X8	X8	X8	X8
N9	X9	X9	X9	X9	X9	X9	0	*
N10	X10	X10	X10	X10	0	*	0	*
N11	X11	X11	0	*	0	*	0	*

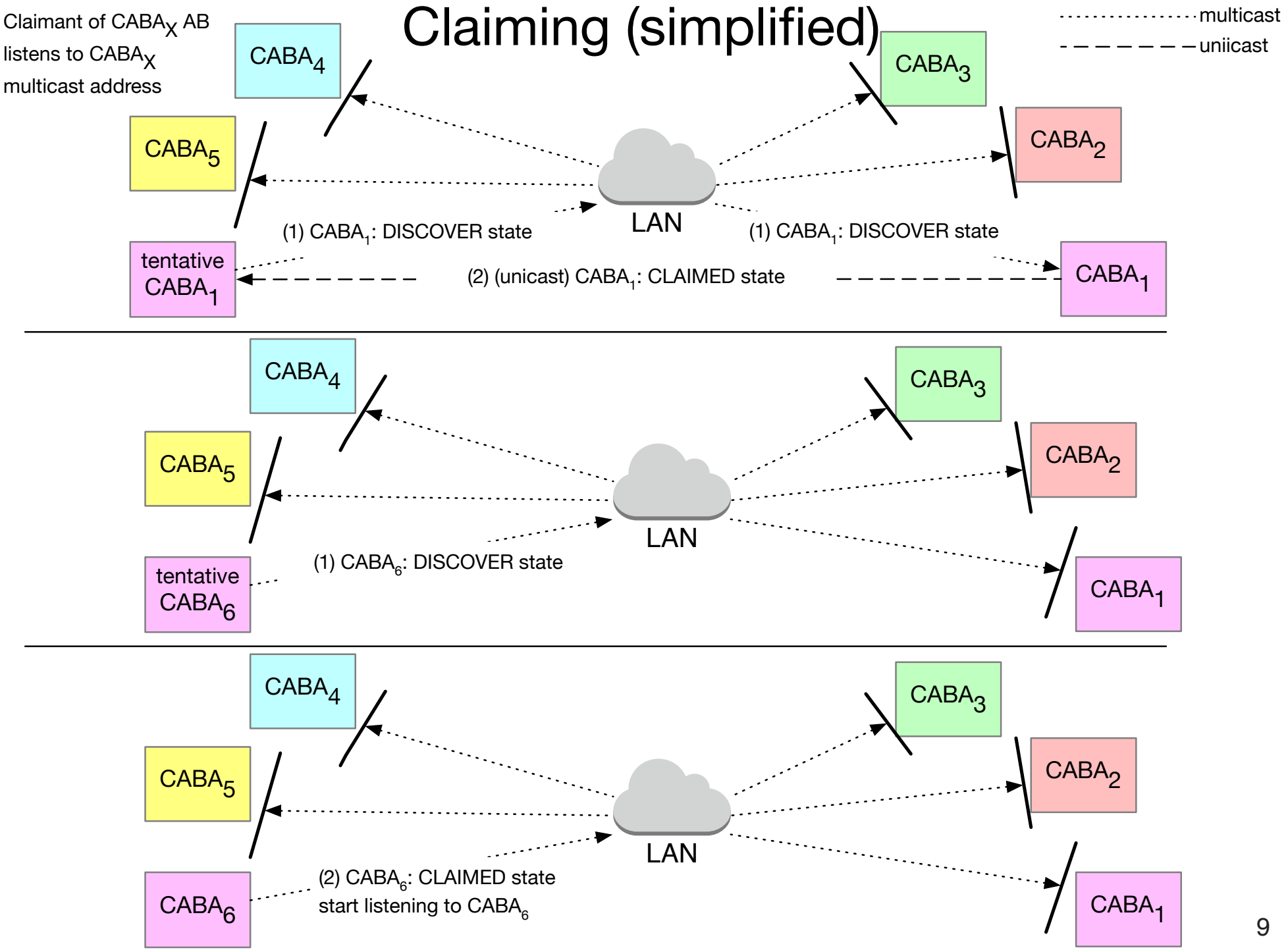
2 contiguous subblocks per CABA (one unicast, one multicast)

CAB Size C=0	CAB Size C=1	CAB Size C=2	CAB Size C=3
• ≈6.9E10 Size 0 CABAs • 1 CA/subblock	• ≈4.3E9 Size 1 CABAs • 16 CAs/subblock	• ≈2.7E8 Size 2 CABAs • 256 CA/subblock	• ≈1.7E7 Size 3 CABAs • 4096 CAs/subblock

N0	r i j k
N1	z y x m

* indicates wildcard (any value)

Claiming (simplified)



Registrar

- Claimant need not be aware of Registrar when initiating a claim.

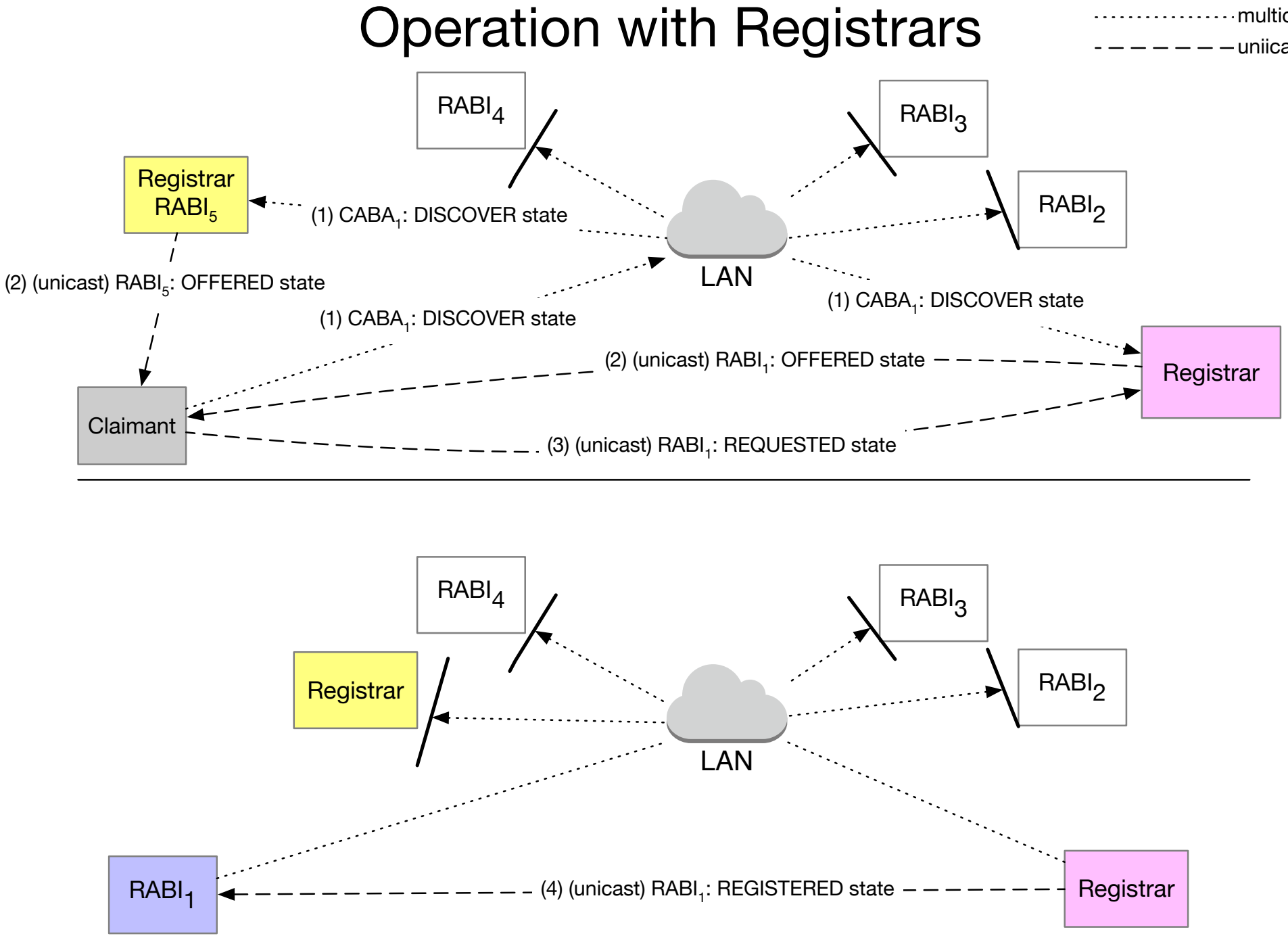
- Registrar maintains an inventory of RABIs.
  - a protocol specifies how Registrars acquire RABIs.
  - set of RABs is disjoint from the set of CABs
    - AB is either claimable (CAB) or registrable (RAB); not both

- Registrar listens for all messages to a CABA.
  - r=0, i=0, m=1, i.e. DA begins 00**-1111
    - [MMRP NumberOfValues field is 13 bits]

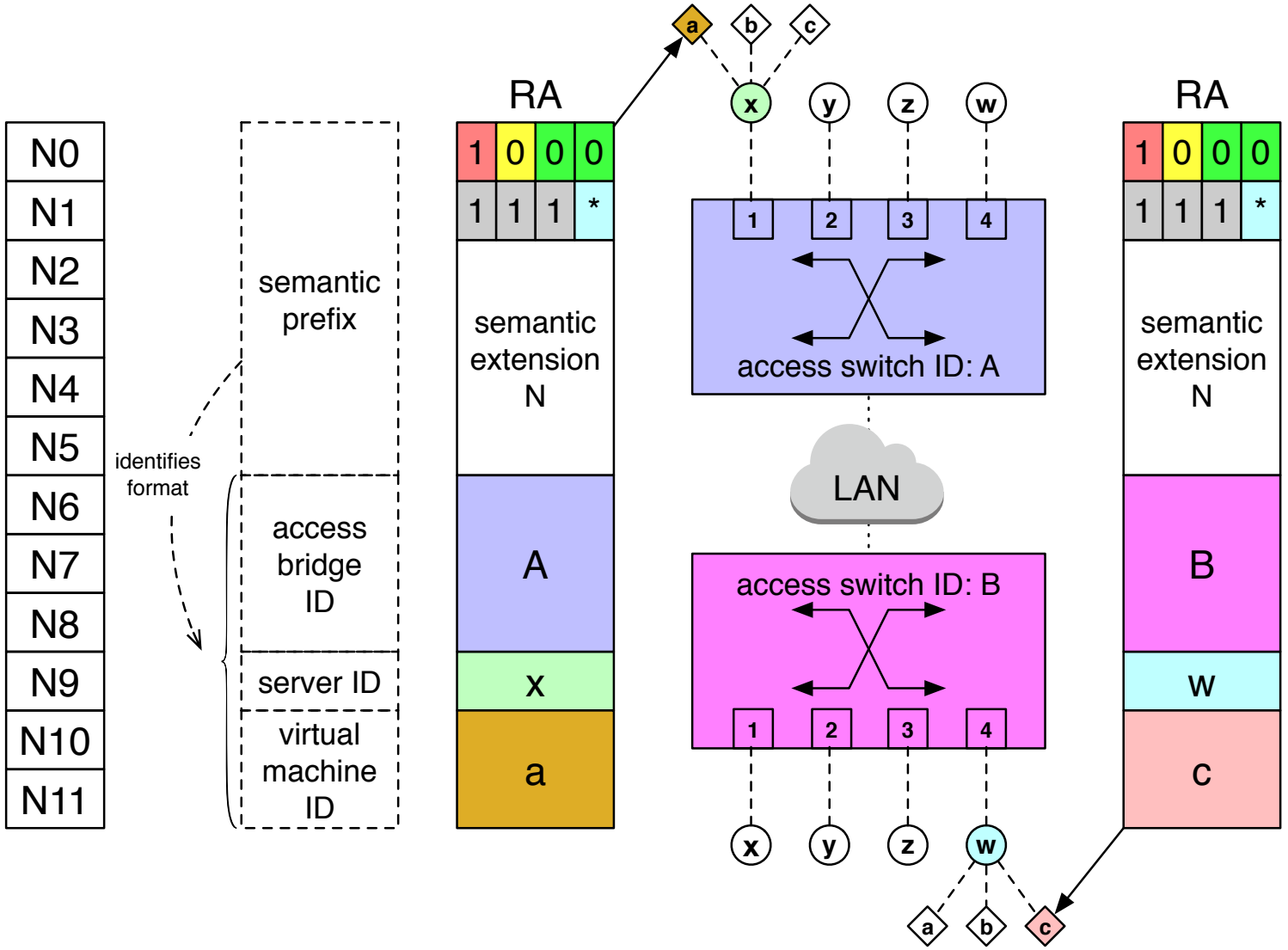
- Registrar can respond to a DISCOVER with an offer of a RABI in its inventory.
  - The offer can also defend the DISCOVER's CABA.
  - Registrar confirms registration of request for offered RABI.

- Pre-claim Inquiry lets Claimant reach Registrar or Advisor.
  - Client can learn of Registrars and received Claim proposals.

Operation with Registrars



Semantic Address Block Assignments



Applications

- General address assignment
  - eliminates need for global addresses
    - reducing consumption
    - may simplify manufacturing
  - maintains uniqueness within the LAN
  - backward-compatible with IEEE 802 addressing and bridging
  - could be useful to address privacy concerns in global addressing
  - provides contiguous unicast and multicast blocks (identical except 1 bit)
- Apply address blocks to structure semantic addresses
  - addressing to reflect topology and hierarchy, as in IP
    - simplified forwarding
  - add flow identification to address
    - useful in forwarding and for other purposes
    - e.g. to multiplex within a single end station
  - combined structure and flow content
    - e.g. flow-zone switching in hyperscale Clos network [3]
  - alternative to completely random assignment; e.g. in wireless
    - dynamic assignment provides MAC address privacy
    - protocol protects against duplication
    - address blocks can code frames for location, flow, stream, etc.
  - bridging of 64-bit addressing in a 48-bit bridged LAN
- Implications to IP need exploration

References

[1] IEEE Standards Project P802.1CQ, “Multicast and local address assignment.” https://1.ieee802.org/tsn/802-1cq

[2] IEEE Standards Association, “IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture – Amendment 2: Local Medium Access Control (MAC) Address Usage,” IEEE Std 802c-2017. https://ieeexplore.ieee.org/document/8016709

[3] Sergio Gonzalez-Diaz, Roger Marks, Elisa Rojas, Antonio de la Oliva, and Robert Gazda, “Stateless flow-zone switching using software-defined addressing,” IEEE Access: 6 May 2021. https://ieeexplore.ieee.org/document/9424558