Emergence of IoT

Computing for Internet of Things

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Overview

1. Addressing in IoT

2. Addressing during Mobility

IPv4 versus IPv6 Addressing

Feature	IPv4	IPv6
Developed	IETF 1974	IETF 1998
Address length (bits)	32	128
No. of Addresses	2^{32}	2^{128}
Notation	Dotted decimal	Hexadecimal
Dynamic allocation of addresses	DHCP	DHCPv6, SLAAC
IPSec	Optional	Compulsary
Header size	Variable	Fixed
Header checksum	Yes	No
Header options	Yes	No
Broadcast addresses	Yes	No
Multicast address	No	Yes
Feature	Focus on reliable transmission	Focus on addressing

IPv6 Address Format

2032 : 8A6F : 3456 : 4F55 : 3342 : AA43 : 3434 : 2267

2032	8A6F	3456	4F55	3342	AA43	3434	2267
GLOBAL PREFIX			SUBNET	INTERFACE IDENTIFIER			

←16-BITS→

←64-BITS→ ←64-BITS→

IPv6 Address Types

The IPv6 addresses can be divided into seven separate address types, which is generally based on how these addresses are used or where they are deployed. These address types are:

- **Global Unicast (GUA)**: These addresses are assigned to single IoT entities/ interfaces, which enables them to transmit traffic to and from the Internet. In regular IoT deployments, these addresses are assigned to gateways, proxies, or WANs.
- **Multicast**: These addresses enable transmission of messages from a single networked entity to multiple destination entities simultaneously.
- **Link Local (LL)**: The operational domain of these addresses are valid within a network segment such as LAN only. These addresses may be repeated in other network segments/ LANs, but are unique within that single network segment.

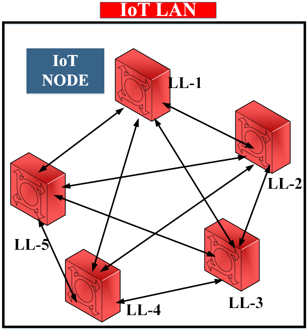
IPv6 Address Types

- **Unique Local (ULA)**: Similar to LL addresses and cannot be routed over the Internet. These addresses may be repeated in other network segments/ LANs, but are unique within that single network segment.
- **Loopback**: It is also known as the localhost address. typically, these addresses are used by developers and network testers for diagnostics and system checks.
- **Unspecified**: Here, all the bits in the IPv6 address are set to zero, and the destination address is not specified.
- **Solicited-node Multicast**: It is a multicast address based on the IPv6 address of an IoT node or entity.

Address Management Classes

- The IoT deployment and network topology are largely dependent on where it is deployed.
- Unlike traditional IPv4 networked devices, the newer IoT devices largely depend on IPv6 for address allocation and management of addresses, which again is dictated by the application and the place of deployment of the IoT solution.
- Keeping these requirements in view, the addressing strategies in IoT may be broadly differentiated into seven classes,

Address Management: Class-1



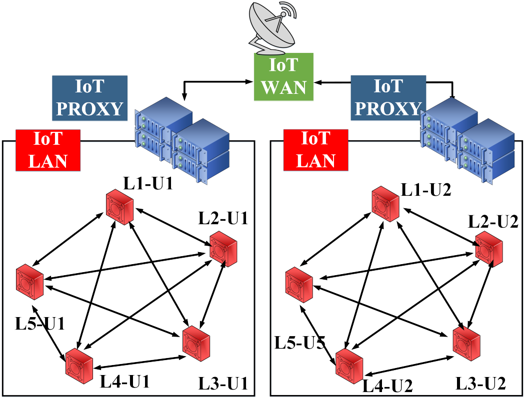
Various IoT topology configurations. LL/L denotes the link local addresses, LU denotes the locally unique link addresses (ULA), and LG denotes globally unique link addresses (GUA)

Address Management Classes

Class-1:

- The IoT nodes are not connected to any other interface or the Internet except with themselves.
- This class can be considered as an isolated class, where the communication between IoT nodes is restricted within a LAN only.
- The IoT nodes in this class are identified only by their Link-Local (LL) addresses.
- These LL addresses may be repeated for other devices outside the purview of this network class.
- The communication among the nodes may be direct or through other nodes (as in a mesh configuration).

Address Management: Class-2



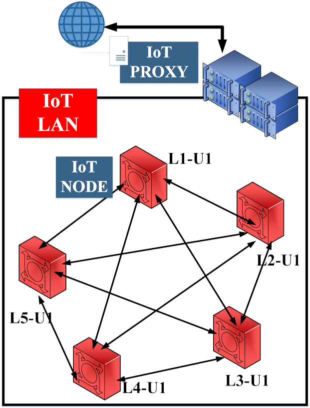
Various IoT topology configurations. LL/L denotes the link local addresses, LU denotes the locally unique link addresses (ULA), and LG denotes globally unique link addresses (GUA)

Address Management Classes

Class-2:

- The class-1 configuration is mainly utilized for enabling communication between two or more IoT LANs or WANs.
- The IoT nodes within the LANs cannot directly communicate to nodes in the other LANs using their LL addresses, but through their LAN gateways (which have a unique address assigned to them).
- Generally, ULA is used for addressing, however in certain scenarios, GUA may also be used.
- L1-L5 are the LL addresses of the locally unique IoT nodes within the LAN, whereas U1 and U2 are the unique addresses of the two gateways extending communication to their LANs with the WAN.
- The WAN may or may not connect to the Internet.

Address Management: Class-3



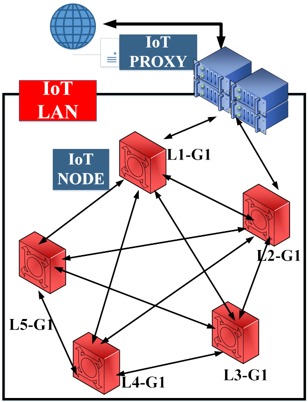
Various IoT topology configurations. LL/L denotes the link local addresses, LU denotes the locally unique link addresses (ULA), and LG denotes globally unique link addresses (GUA)

Address Management Classes

Class-3:

- The IoT LAN connects to an IoT proxy.
- The proxy performs a host of functions ranging from address allocation, address management to providing security to the network underneath it.
- In this class, the IoT proxy only uses ULA (denoted as Lx-Ux in the figure).

Address Management: Class-4



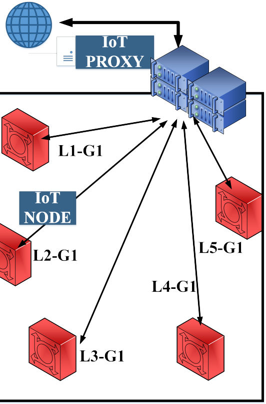
Various IoT topology configurations. LL/L denotes the link local addresses, LU denotes the locally unique link addresses (ULA), and LG denotes globally unique link addresses (GUA)

Address Management Classes

Class-4:

- In this class, the IoT proxy acts as a gateway between the LAN and the Internet, and provides GUA to the IoT nodes within the LAN.
- A globally unique prefix is allotted to this gateway, which it uses with the individual device identifiers to extend global Internet connectivity to the IoT nodes themselves.
- An important point to note in this class is that the gateway also enables local communication between the nodes without the need for the packets to be routed through the Internet.
- Additionally, the IoT nodes within the gateway can talk to one another directly without always involving the gateway.
- A proxy beyond the gateway enables global communication through the Internet.

Address Management: Class-5



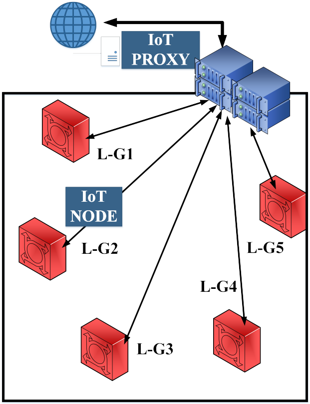
Various IoT topology configurations. LL/L denotes the link local addresses, LU denotes the locally unique link addresses (ULA), and LG denotes globally unique link addresses (GUA)

Address Management Classes

Class-5:

- This class is functionally similar to class-4.
- The main difference with class-4 is that this class follows a star topology with the gateway as the center of the star.
- All the communication from the IoT nodes under the gateway has to go through the gateway.
- A proxy beyond the gateway enables global communication through the Internet.
- The IoT nodes within a gateway's operational purview have the same GUA.

Address Management: Class-6



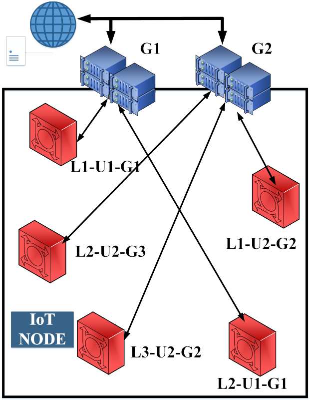
Various IoT topology configurations. LL/L denotes the link local addresses, LU denotes the locally unique link addresses (ULA), and LG denotes globally unique link addresses (GUA)

Address Management Classes

Class-6:

- The configuration of this class is again, similar to class-5.
- The IoT nodes are all assigned unique global addresses (GUA), which enables a point-to-point communication network with an Internet gateway.
- Typically, this class is very selectively used for special purposes.

Address Management: Class-7



Various IoT topology configurations. LL/L denotes the link local addresses, LU denotes the locally unique link addresses (ULA), and LG denotes globally unique link addresses (GUA)

Address Management Classes

Class-7:

- Multiple gateways may be present, and the configuration has been such that the nodes should be reachable through any of the gateways.
- Typically organizational IoT deployments follow this class of configuration.
- The concept of multihoming is important and inherent to this class.

Tunnelling

- It is a networking protocol in which data from private networks can be seamlessly streamed over a public network in the form of encapsulated packets.
- This is mainly used for ensuring connectivity and security of data generated from various technologies and protocols, which may not be supported over the public communication channel.
- Some of the best examples of tunneling are Virtual Private Networks (VPNs), Secure Shell (SSH), and others.

Multihoming

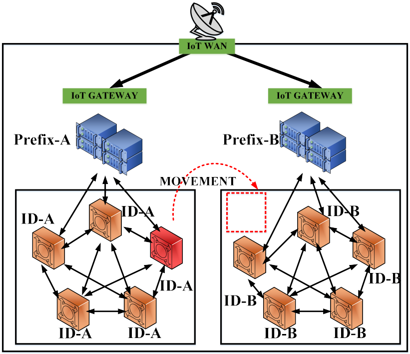
- It is a network configuration in which a node/network connects to multiple networks simultaneously for improved reliability.
- Network proxies are used to manage multiple IP addresses and map them to LL addresses of IoT nodes in small deployments, where the allotment of address prefixes is not possible.
- Other approaches for multihoming include the use of gateways for assigning LL addresses to IoT nodes under the gateway's operational purview.

Addressing during Node Mobility

- The traditional networks, mainly the computer networks, and even paradigms such as M2M and CPS seldom take into account the need for addressing strategies when the IoT nodes are mobile.
- However, in a realistic scenario, especially in modern-day IoT systems (which are low-power and low form-factor) the need for addressing of mobile nodes is extremely crucial to avoid address clashes at the same time accommodating a large number of IoT nodes.
- Typically, three strategies may be used for ensuring portability of addresses in the event of the occurrence of node mobility in IoT deployments.

Addressing during Global Prefix changes

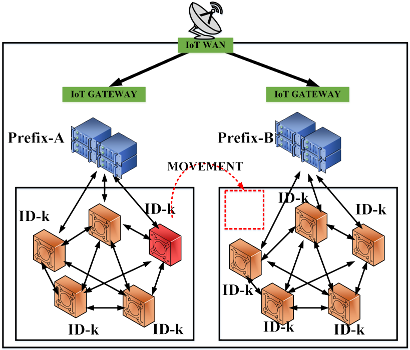
1. A node from the left LAN moves to the LAN on the right.
2. The node undergoing movement is highlighted in the figure. The nodes in the first LAN have the prefix **A**, which changes to **B** under the domain of the new gateway overseeing the operation of nodes in the new LAN.
3. However, it may happen that due to movement, the device identifier may face clashes.
4. The device identifier, if allotted randomly, might face address clash upon the node's arrival into the new LAN as there may be already a similar node identifier present in it.
5. Typically, addresses are assigned using DHCPv6/ SLAAC; however, in this scenario, it is always prudent to have static node IP addresses to avoid a clash of addresses.
6. This strategy is, in most cases, most beneficial as the IoT nodes may be resource-constrained and have low-processing resources.



ID-*prefix* denotes the point to which the IoT node is attached to for address allocation

Addressing during changes within WANs

1. In case the WAN changes its global prefix, the network entities underneath it must be resilient to change and function normally.
2. The address allocation is hence delegated to entities such as gateways and proxies, which make use of ULAs to manage the network within the WAN.



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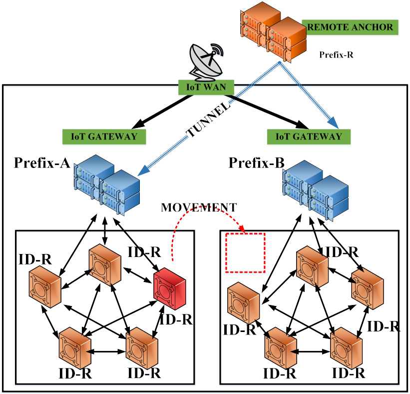
Addressing through Remote Anchoring

1. This is applicable in certain cases, which require that the IoT node's global addresses are maintained and not affected by its mobility or even the change in network prefixes.
2. Although a bit expensive to implement but this strategy of having a remote anchoring point from which the IoT nodes obtain their global addresses through tunneling ensures that the nodes are resilient to changes and are quite stable.
3. Even if the node's original network's (LAN) prefix changes from **A** to **B**, the node's global address remains immune to this change.



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The End