Introduction to IPv6

PASI (Pan-American Advanced Studies Institute)

Grid Computing and Advanced Networking Technologies for e-Science

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Agenda

- History
- Comparison between IPv4 x IPv6
- Migration Strategy
- Final Considerations

History

- IP (Internet Protocol) was specified in the end of 70's through the RFC 791.
- 1991 - IETF decided to specify a new version of the IP protocol called IPng (IP next generation) or IPv6 (IP version 6).
- 1994 – the main features of IPv6 were defined.

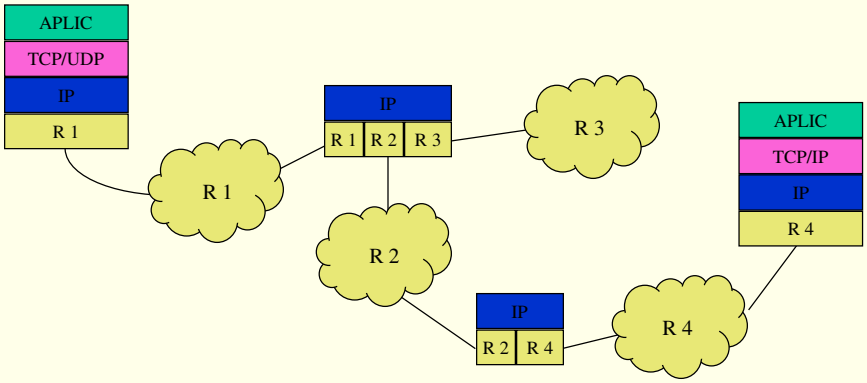
IPv6

- Its development has started in the beginning of 90's by IETF (*Internet Engineering Task Force*).
- **Motivation**: Lack of IP address in short-term, since new networks have been connected at an increasing rate to the Internet.
- Based on IPv4 experience, the IPv6 designers take this opportunity for changing and adding new characteristics.

IP (Internet Protocol)

IP Function

Message Transport through different subnets until its destiny.



IP (Internet Protocol)

- The IP layer is responsible for data forwarding within a TCP/IP network.
  - Defines the network basic transmission unit: **Datagram**.
  - Defines the host addressing scheme: **IP address**.
  - It is responsible for the routing function, selecting the datagram route in the network.
- All other protocols (**TCP, UDP, ICMP e IGMP**) are transmitted in the network as **IP datagrams**.
- The IP Layer provides a **non-reliable packet delivery service** without connection (**connectionless** service).
  - Datagrams can be lost, duplicated, delayed or delivered out of order.
- Defined by RFC 791.

Comparison IPv4 x IPv6

- The main differences between IPv4 e IPv6 include:
  - Addressing.
  - Network address translation.
  - Routing.
  - Security.
  - Administrative workload.
  - Support to mobile devices.

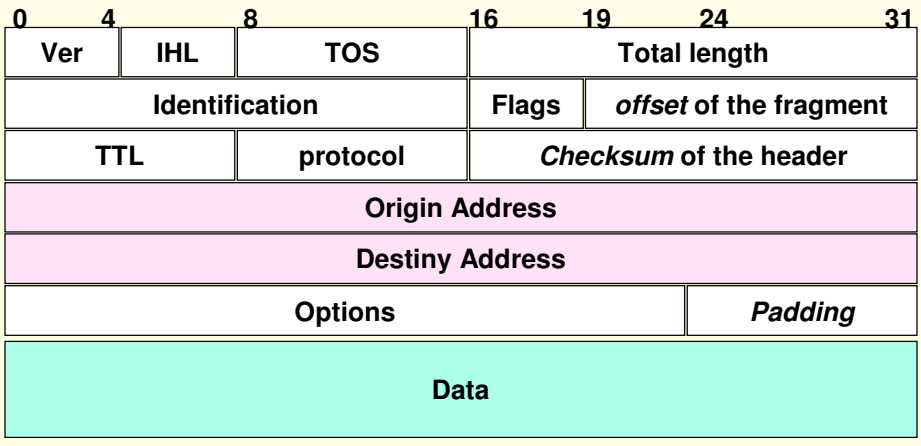
Datagram Format

- **IPv4**
  - Checksum in the header.
  - Option Field, limited to 40 bytes.
  - No mechanism for the definition of traffic flow.
- **IPv6**
  - No Checksum in the header.
  - Extension headers with random sizes.
  - Possibility of associating several datagrams to the same traffic flow.

IPv4 Datagram

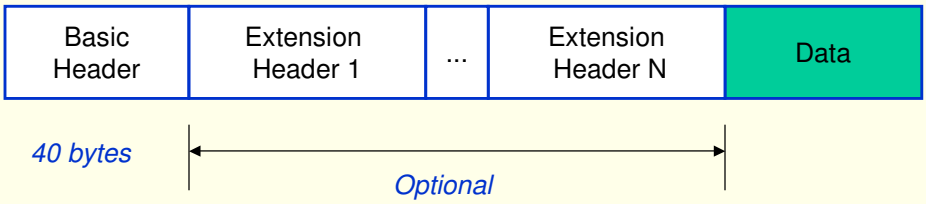
- The IPv4 datagram header has 24 bytes, 12 of them are used for additional information and 4 for options.
- This information in IPv6 is contained in the extension headers.

IPv4 Datagram

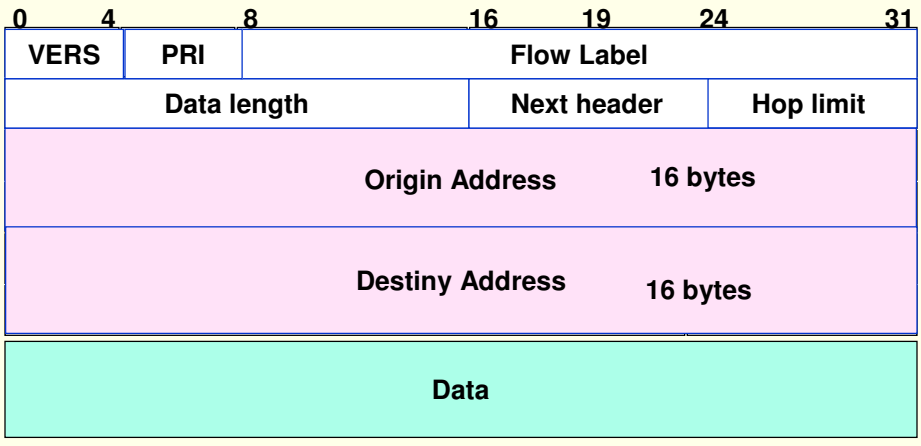


IPv6 Datagram

- The IPv6 datagram has a simpler format. The IPv6 has a basic header with fixed length and zero or more extension headers.
- This solution presents great flexibility, because each datagram includes only the necessary headers for the corresponding communication.



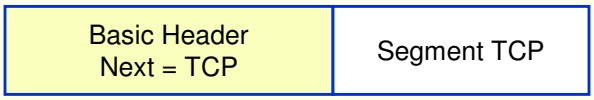
IPv6 Datagram

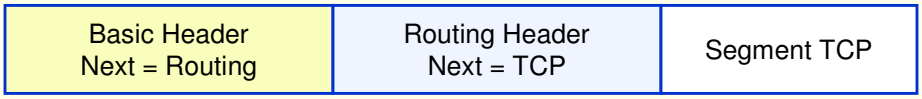


Extension Headers

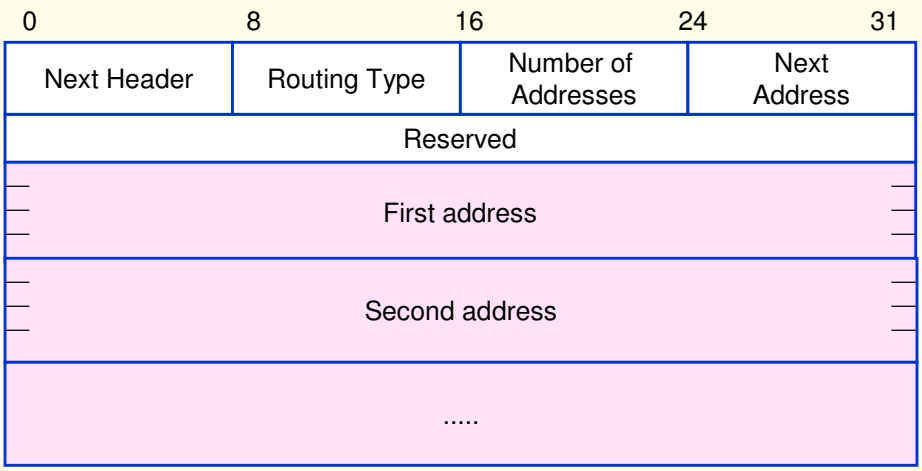
- For additional functions, IPv6 uses 6 types of extension headers:
  - **Hop-by-Hop Header.**
  - **Routing Header:**
    - Source Demand Routing Protocol (SDRP).
    - It contains the list of IP addresses to be visited.
  - **Fragmentation Header:**
    - The fragmentation can only be performed by the origin node.
  - **Authentication Header.**
  - **Encrypted Security Payload:**
    - Contains the cryptographied payload.
    - The standard algorithm is the DES (Data Encryption Standard).
  - **Destination Options Header.**

Examples of Extension Headers





Routing Header Format



Addressing

- **IPv4**
  - Maximum Size of the address field is **32** bits.
  - There are five addressing classes: A, B, C, D e E.
  - Each address has two parts: **network address** and **host address**.
  - Multicast support is optional (D Class).
  - Representation of each byte in e decimal separated by points:
    - 147.100.10.5
- **IPv6**
  - Maximum Size of the address field is **128** bits.
  - There are 3 service classes:
    - unicast
    - anycast
    - multicast
  - Each address type has a different format.
  - Representation in hexadecimal separated by double points:
    - 3ffe:190:4545:3:f8ff:2:de21:67ca

Addressing

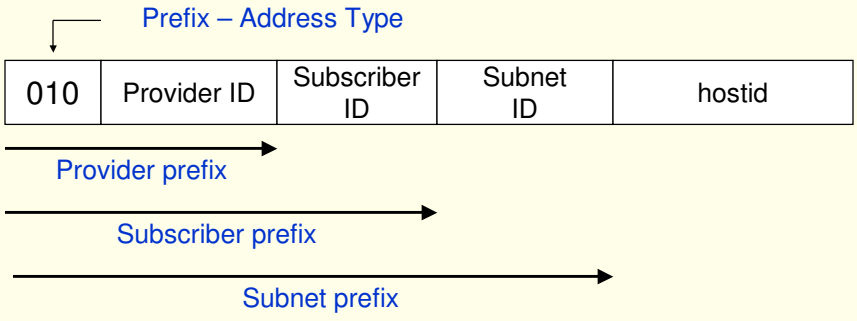
- **Unicast Address:**
  - Prefix Format
  - Register Identifier.
  - Provider Identifier.
  - Subscriber Type.
  - Subscriber Identifier.
  - Subnet Identifier.
  - Interface Identifier.

Local address: combination with MAC address.

- **Anycast Address:** definition of a group for receiving and sending packets. (e.g, DNS servers).

Address Structure – IPv6

- As IPv4, the IP address is assigned to interfaces and not to nodes.
- IPv4 uses ana hierarchy of 2 levels (*netid e hostid*). IPv6 allows the usage of a multi-level hierarchy.



Fragmentation

- **IPv4**
  - The fragmentation can be performed in every gateway used the subnets interconnection.
- **IPv6**
  - The fragmentation is done by the source node.

Routing

- **IPv4**
  - Supports the basic routing protocols.
  - Source routing can be performed by some application from the superior layers.
- **IPv6**
  - Supports the basic routing protocols.
  - Source routing can be implemented using the routing extension header.

Security

- **IPv4**
  - There are no security mechanisms.
  - Need for the implementation of new protocols to support VPN.
- **IPv6**
  - Supports security mechanisms used in the implementation of the authentication, non-repudiation, integrity and confidentiality services.
  - Supports security extension headers.
  - Supports a native VPN implementation.

Error Control and Address Resolution

- **IPv4**
  - Error control performed by ICMP.
  - Translation of logic and physical addresses upon the usage of the ARP e RARP protocols.
  - Multicast Member Control performed by IGMP.
- **IPv6**
  - Error control.
  - Translation of logic and physical addresses and multicast member control performed by the ICMP.

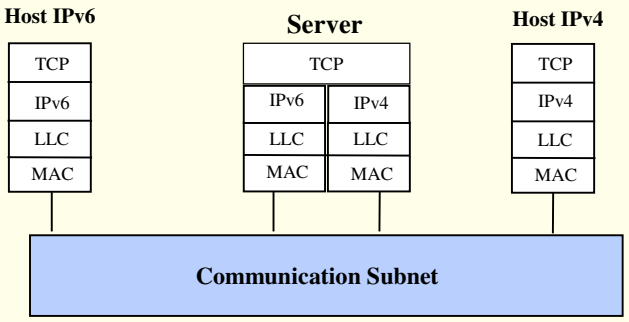
Migration Strategy

- Two basic questions:
  - How 2 IPv6 machines or subnets can communicate between themselves if they are interconnected through IPv4 networks?
  - How a IPv4 client application can communicate with an IPv6 server? And a IPv6 client with a IPv4 server?

Migration Strategy

- The main migration strategies are:
  - IPv6 Tunelling in IPv4.
  - IPv4 Tunelling in IPv4.
  - Dual Stack:
    - Two protocol stacks: IPv4 e IPv6 in the same machine.

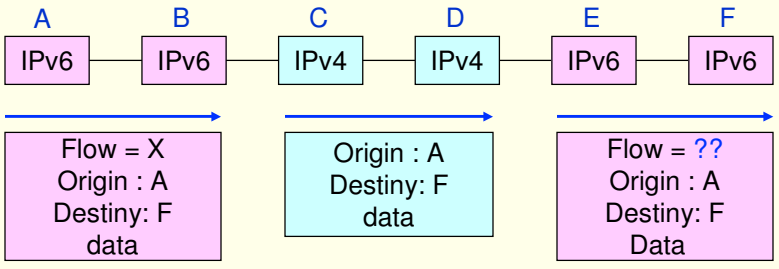
Migration Strategy



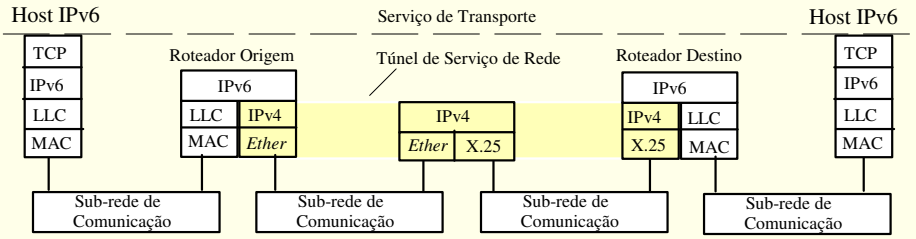
Dual Stack

Dual Stack

- Not all IPv6 fields can be mapped in IPv4.

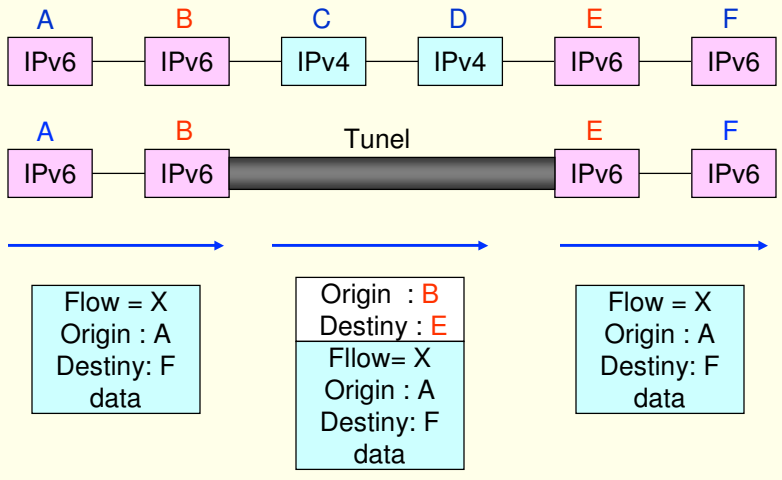


Migration Strategy



IPv6 Tunelling in IPv4 network

Tunelling



Final Considerations

- **IPv6:**
  - **Address limitation.**
  - **Simplification of routers:**
    - Fixed size IP Header.
    - Extension Header: source
    - Usage of traffic flows→ Quality of Service.
    - Fragmentation done in the origin.
  - **Security:**
    - Native security functions.
  - **Support of Multimedia applications:**
    - Traffic Prioritization
    - Usage of traffic flow.

Final Considerations

- **Greater adressing capacity.**
  - 128 bits of address based on hierarchical structure.
- **New type of address** - ***anycast***
  - Facilitate communication between any two group of stations.
- **40 byte-header**
  - Greater processing speed-up.
- **Flow and priority**
  - Transmission with QoS.
- **Support for Mobility**.

Acknowledgments

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