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Adaptive Address for Next Generation IP Protocol in Hierarchical Networks

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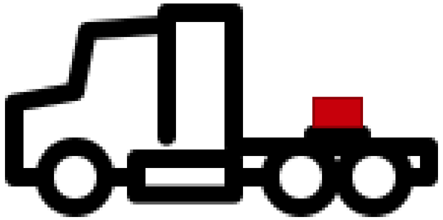
Motivation



Header Overhead

- Short messages
- Energy sensitive
- Delay sensitive
- Resource limit

Address Extensibility

- Independent address space
- Identity retention
- Nondisruptive upgrade

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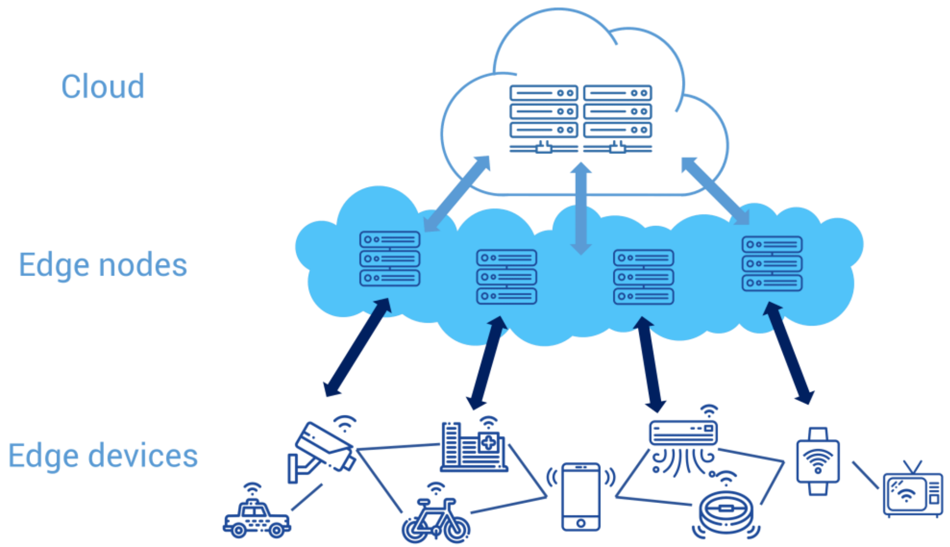
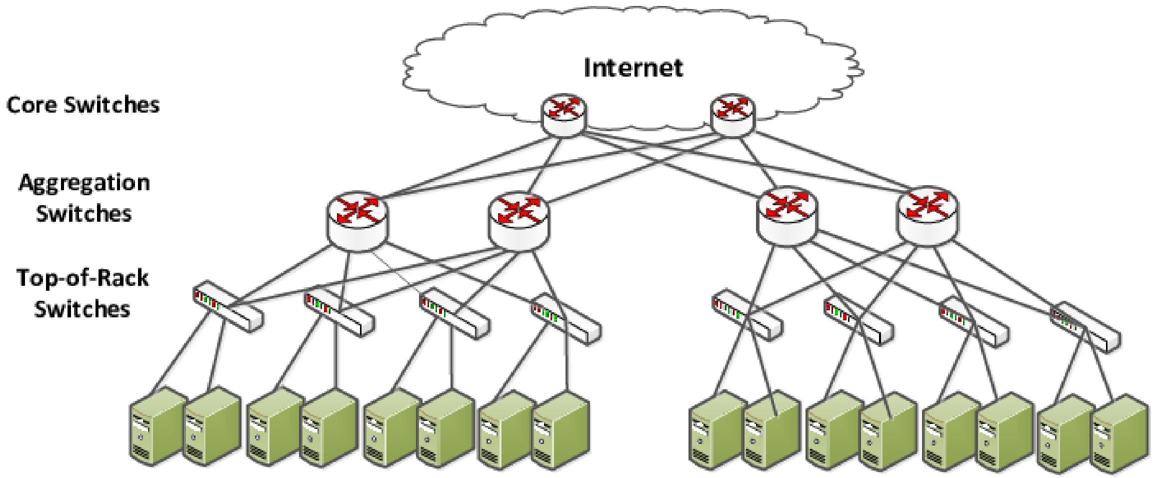
Observation



IoT Network



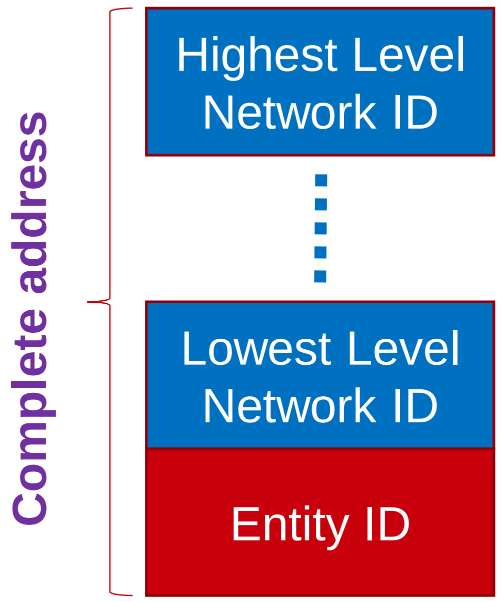
Data Center Network

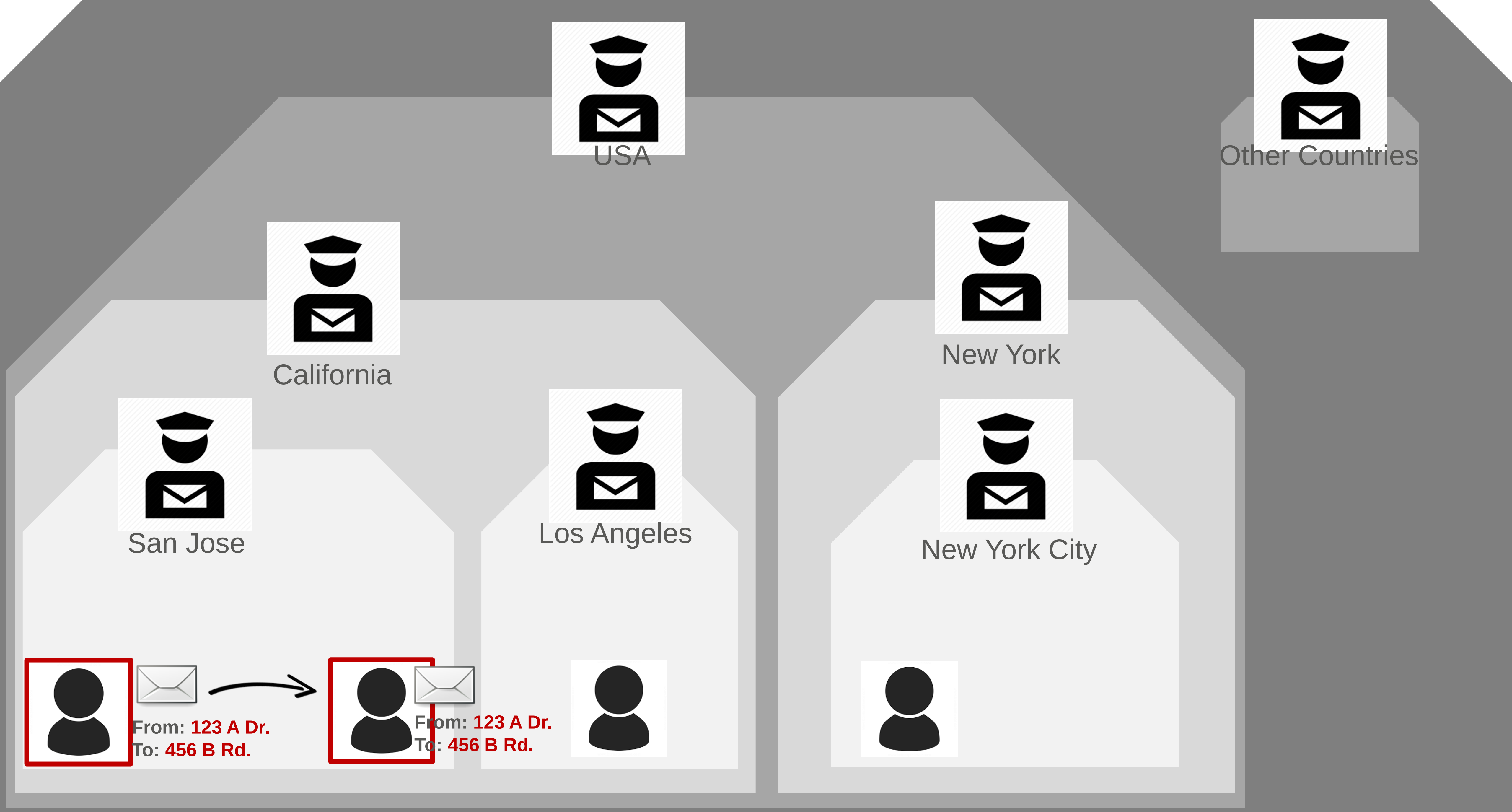
- Hierarchical network architecture
- Most communication happens between adjacent entities
- Communication possible if entities can be uniquely identified ***mutually***

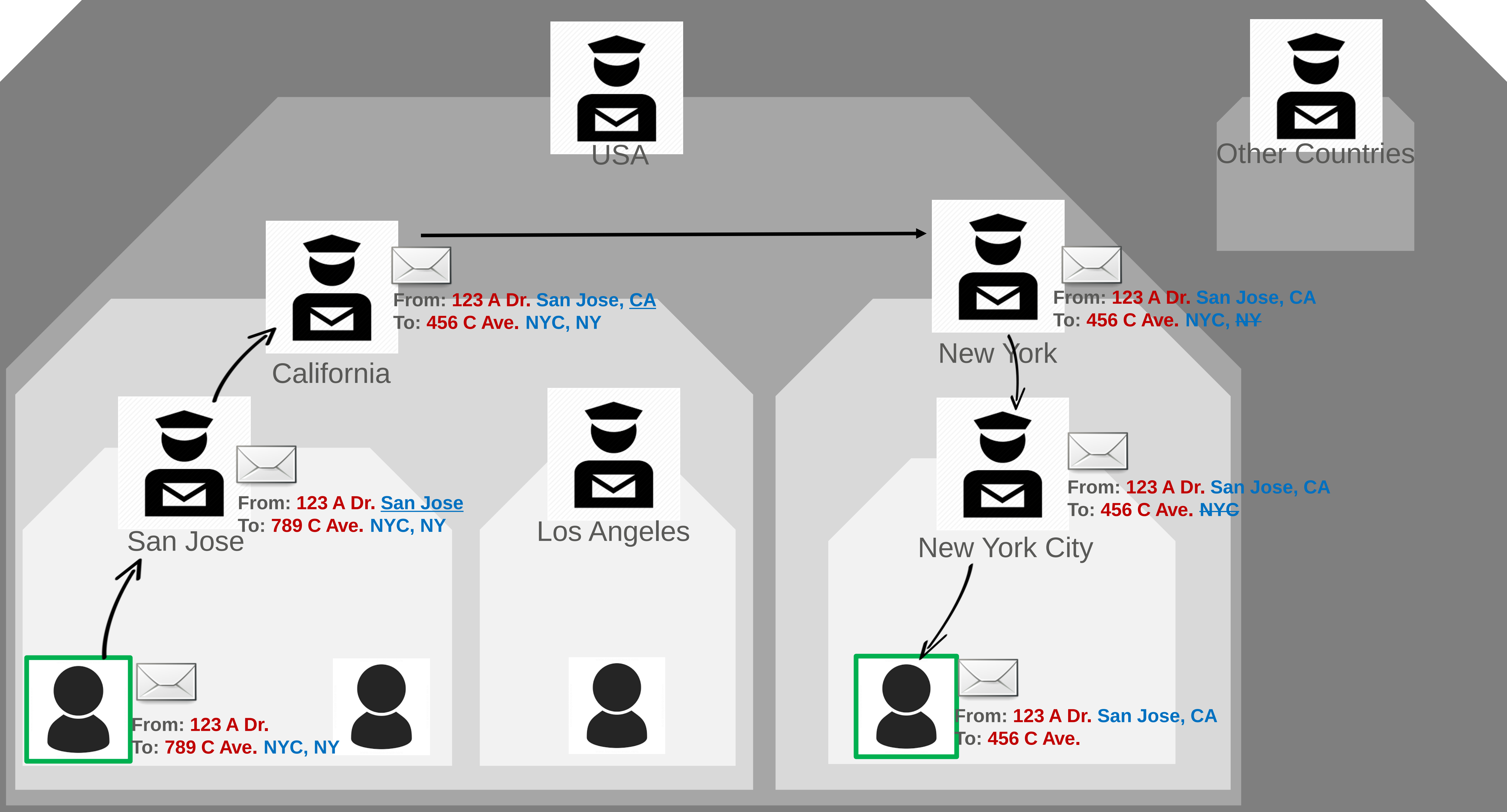
Adaptive Address in Hierarchical Networks

Entity Address* = *Network ID* + *Entity ID

- ***Delegate*** Network ID maintenance and operation to networks
- Entity only knows and uses its own Entity ID
- For communication, entity only get the peer's partial address up to the first network level they share
  - E.g., in the lowest level network, entity ID is enough



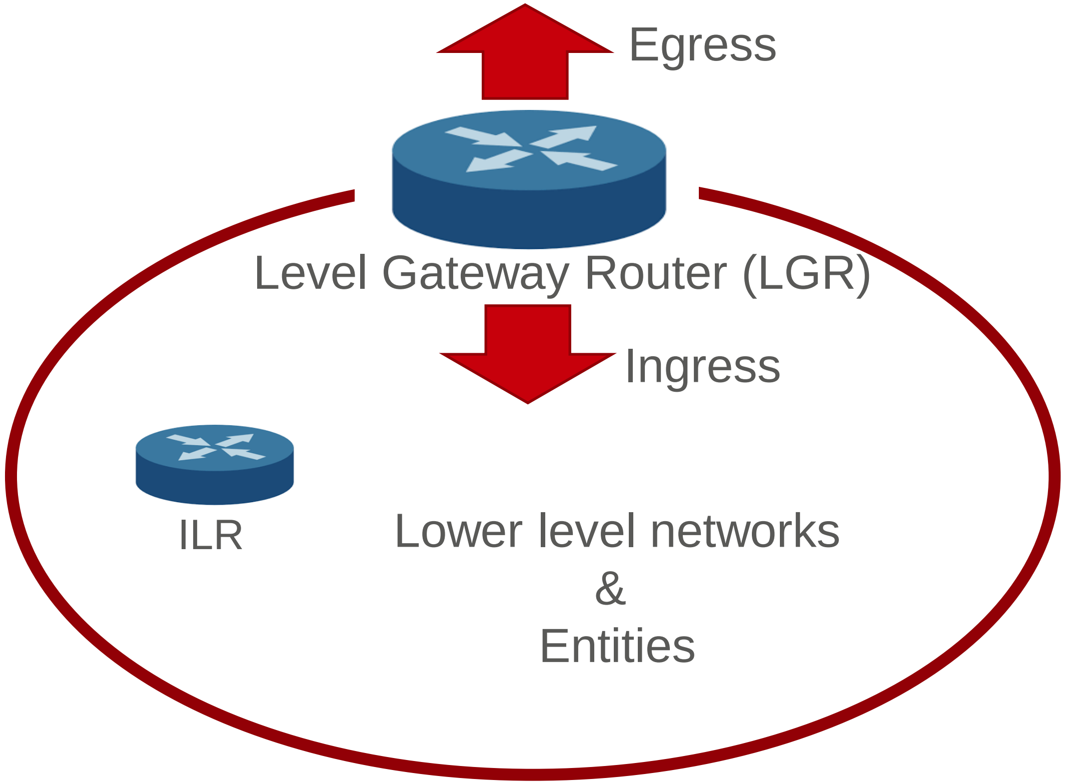

USA
Other Countries
California
New York
San Jose
Los Angeles
New York City
From: 123 A Dr.
To: 456 B Rd.
From: 123 A Dr.
To: 456 B Rd.


USA
Other Countries
California
From: 123 A Dr. San Jose, CA
To: 456 C Ave. NYC, NY
New York
From: 123 A Dr. San Jose, CA
To: 456 C Ave. NYC, NY
San Jose
From: 123 A Dr. San Jose
To: 789 C Ave. NYC, NY
Los Angeles
New York City
From: 123 A Dr. San Jose, CA
To: 456 C Ave. NYC
From: 123 A Dr.
To: 789 C Ave. NYC, NY
From: 123 A Dr. San Jose, CA
To: 456 C Ave.

Address Fields in Header & Border Router’s Function

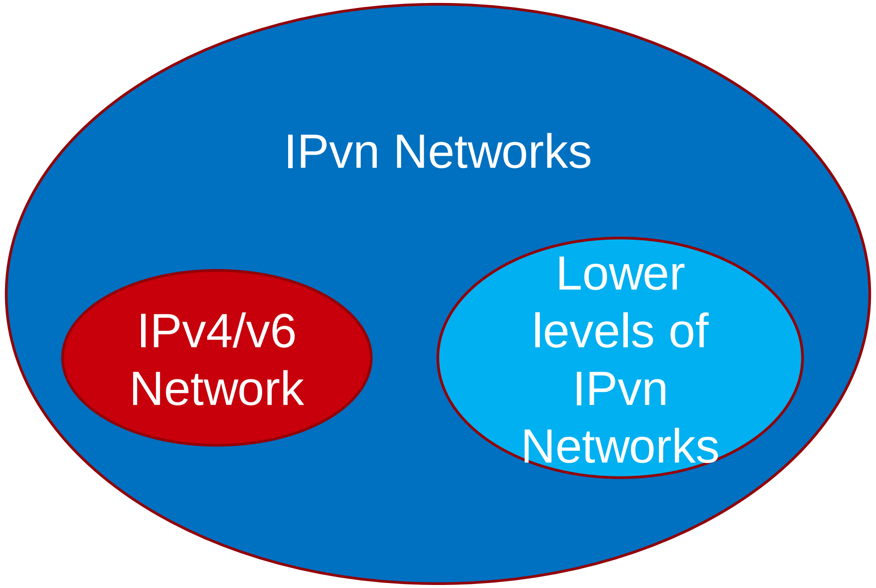
Src. Addr. Length	Dst. Addr. Length
Source Address (variable)	
Destination Address (variable)	

- LGR keeps a prefix (network ID) for the network below it
  - Egress packet: add the prefix to the source address
  - Ingress Packet: remove the prefix from the destination address
- ILR for intra-level traffic forwarding

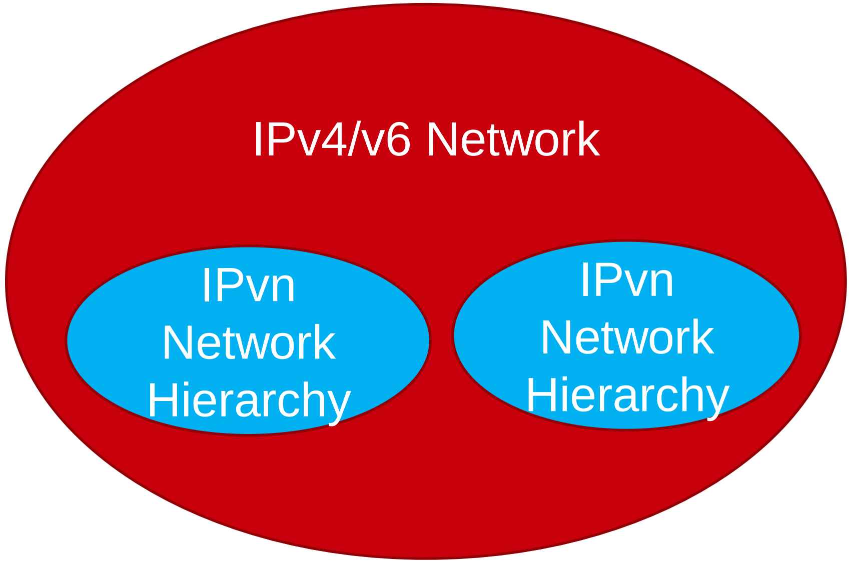


Interface with IPv4/IPv6 Networks

IPv4/IPv6 Network as a lowest level network in IPvn



IPvn networks within IPv4/IPv6 network



- IPvn with private addresses (NAT)
- **IPvn with assigned public address block**
    - LGR → IPT (IP Protocol Translator)

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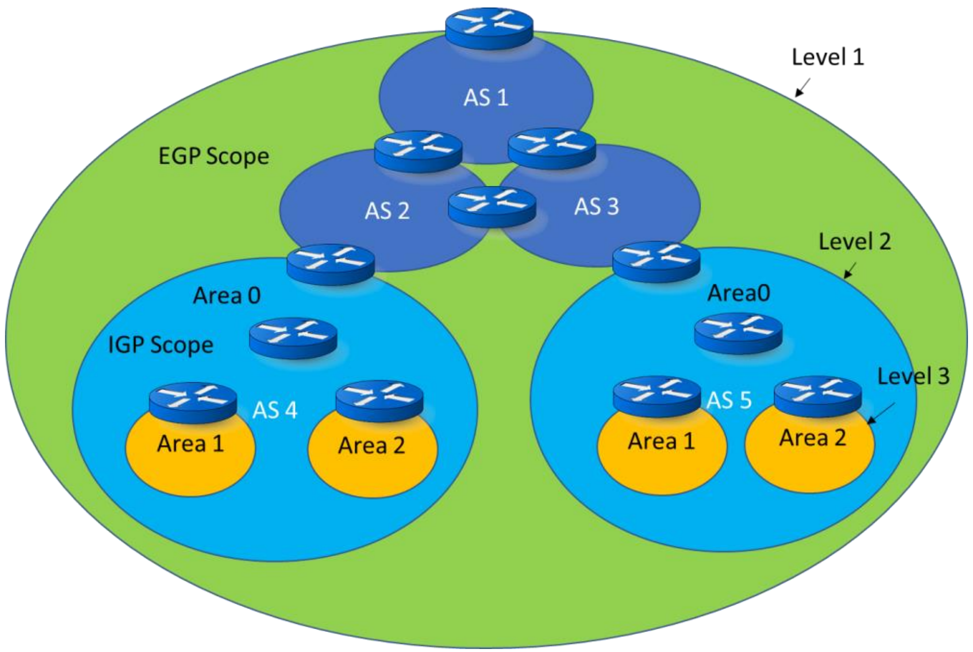
Control Plane Design

- DHCP
  - Entity ID assignment
- DNS
  - Hierarchical tree architecture
  - Name scoping and name overriding
- ARP/NDP
  - LGR as ARP proxy for its prefix
- Routing Protocol
  - Low level network can be a single AS
  - High level network can contain multiple ASes
    - With lower level network as stub AS



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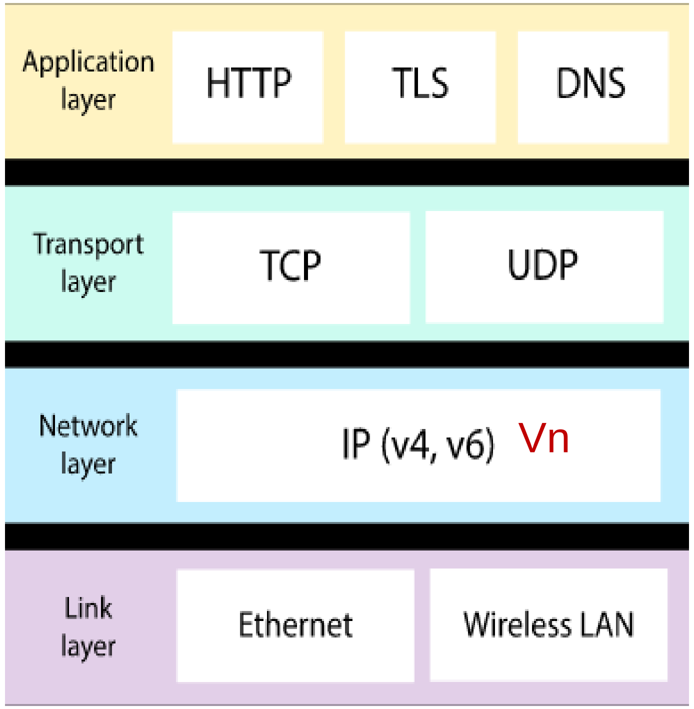
Data Plane Design

- End Entity
  - New IPvn socket supporting IPvn address family
  - Header convertible to IPv4/IPv6
  - Same L2, and L4-L7 protocol stack
- Routers
  - Smaller and simplified forwarding table
    - No nested prefixes
    - Network level address aggregation
  - New functions in LGR
    - Source and destination address manipulation
  - New functions in IPT
    - IP protocol translation



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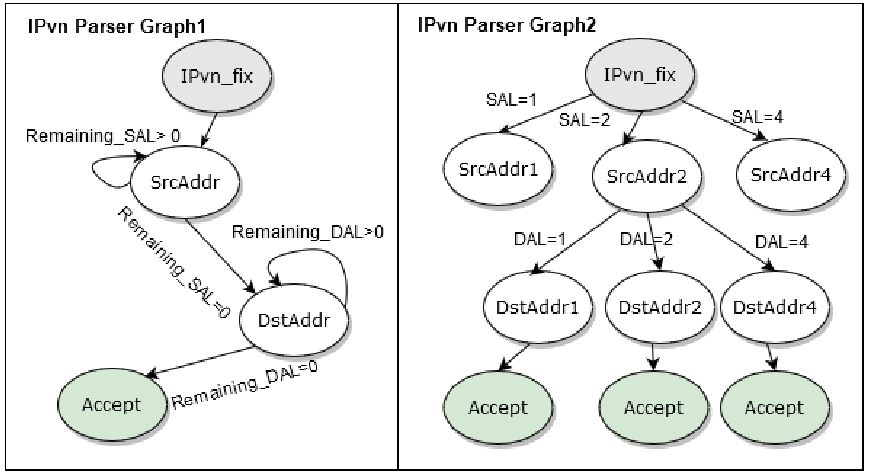
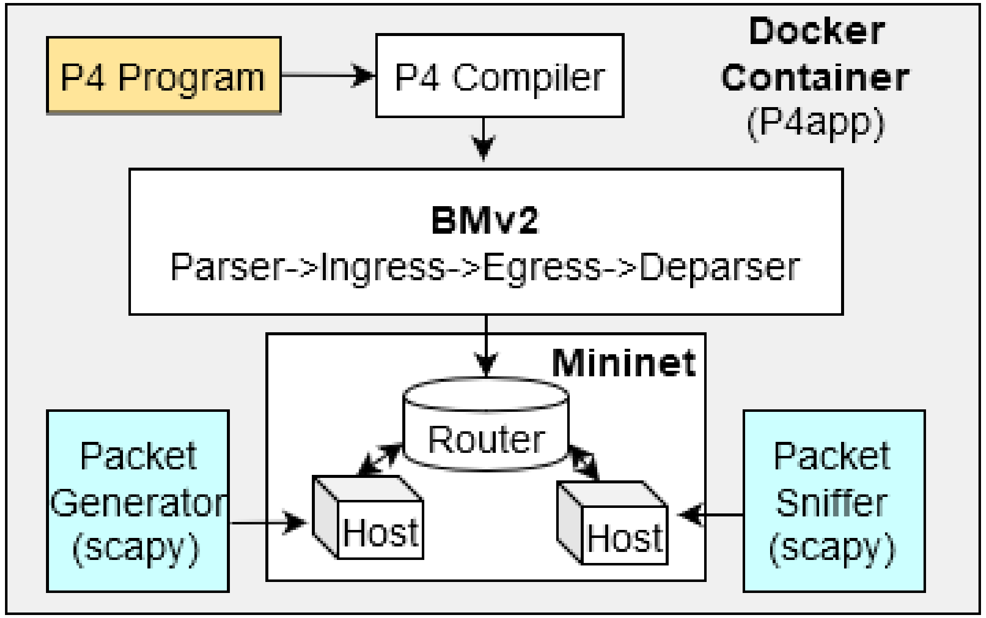
Implementation

Ver(8)	Header Length	ToS/TC	Next Header	Hop Limit/TTL
Payload Length			SAL	DAL
SA		DA		Padding

IPVn header format

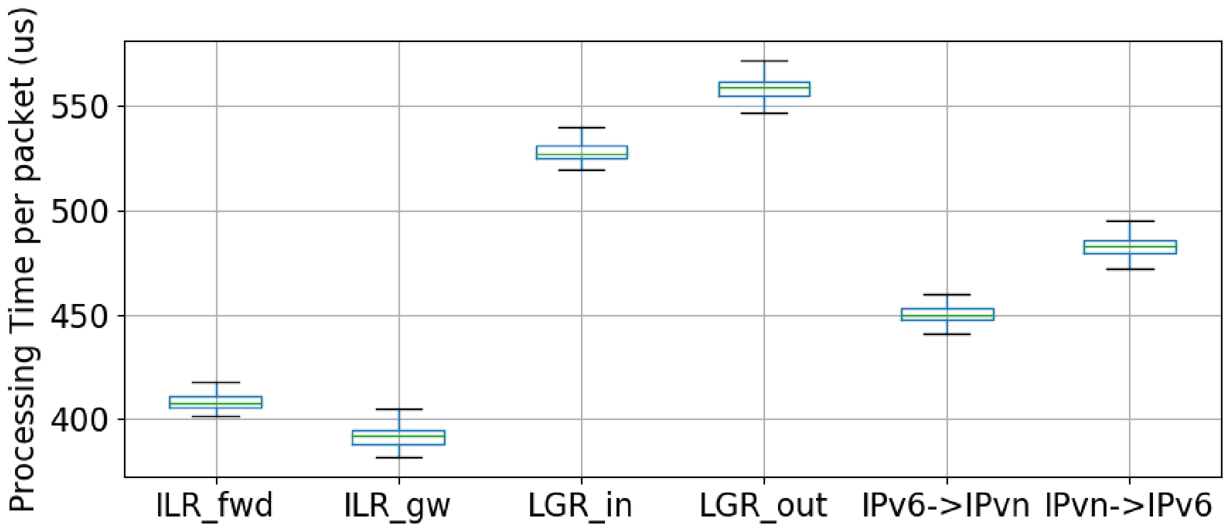


IPVn header parse graph in P4

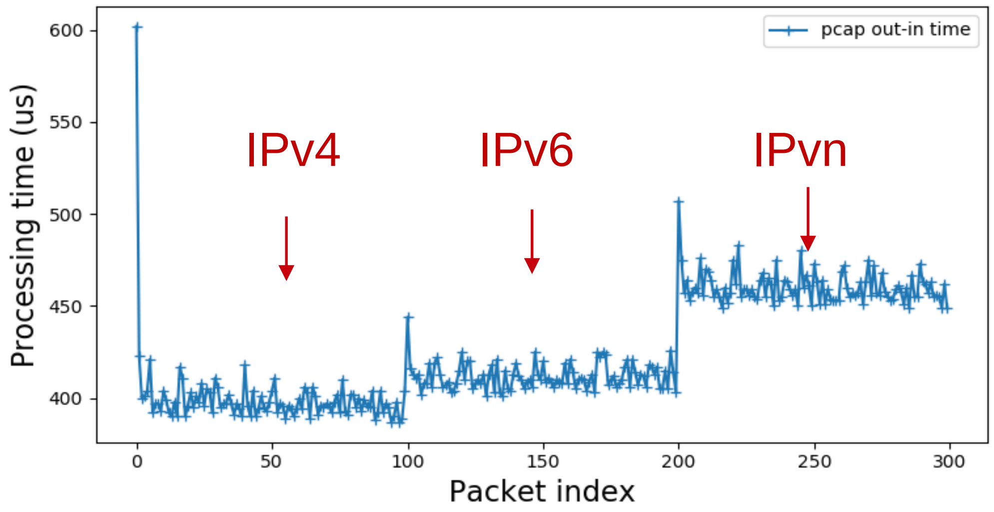


Implementation and Simulation Environment

Evaluation I



Per-Packet Processing Time in Different Types of Routers



Forwarding Performance Comparison

- Reflect relative performance in software implementation
- Insufficient support of variable length header in P4
- Not consider the performance for address lookups

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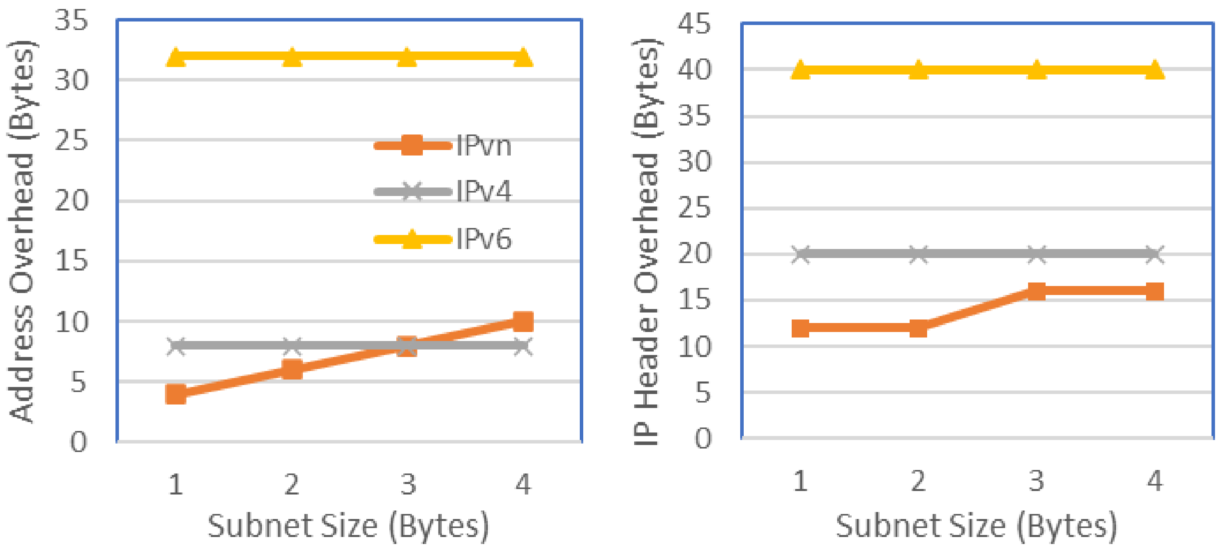
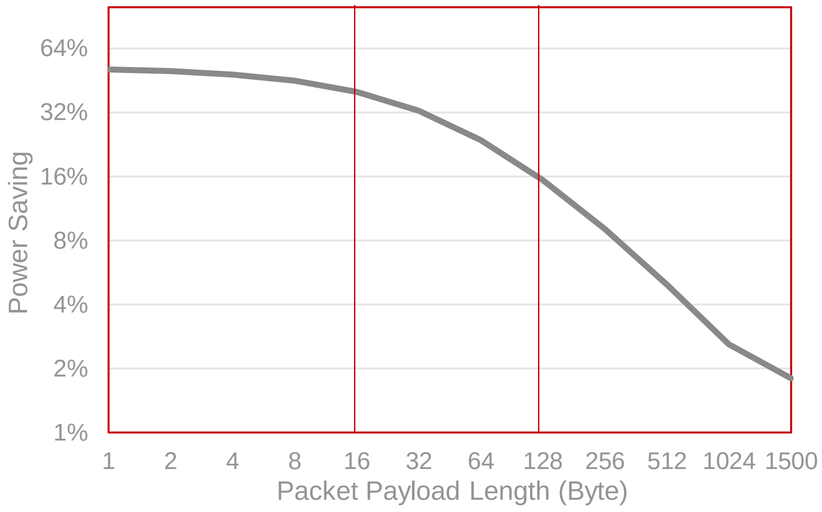
Evaluation II



Overhead Comparison



IoT Power Saving over IPv6

Conclusion

- Efficient addressing scheme for IoT and data center networks
- Future-proof extensible address space
- Incrementally deployable from the edge
- Fully interoperable with existing IPv4/IPv6 network and end entities
- Simplified network control/data plane protocol & implementation
- Open source (https://github.com/Fizzbb/ResearchPaper/tree/master/Adaptive-Addresses-for-NG-IP)

Thank You.