

**1st ACM SIGCOMM Workshop on Future of Internet
Routing & Addressing (FIRA)**

Topological Addressing Enabling Energy Efficient IoT Communication

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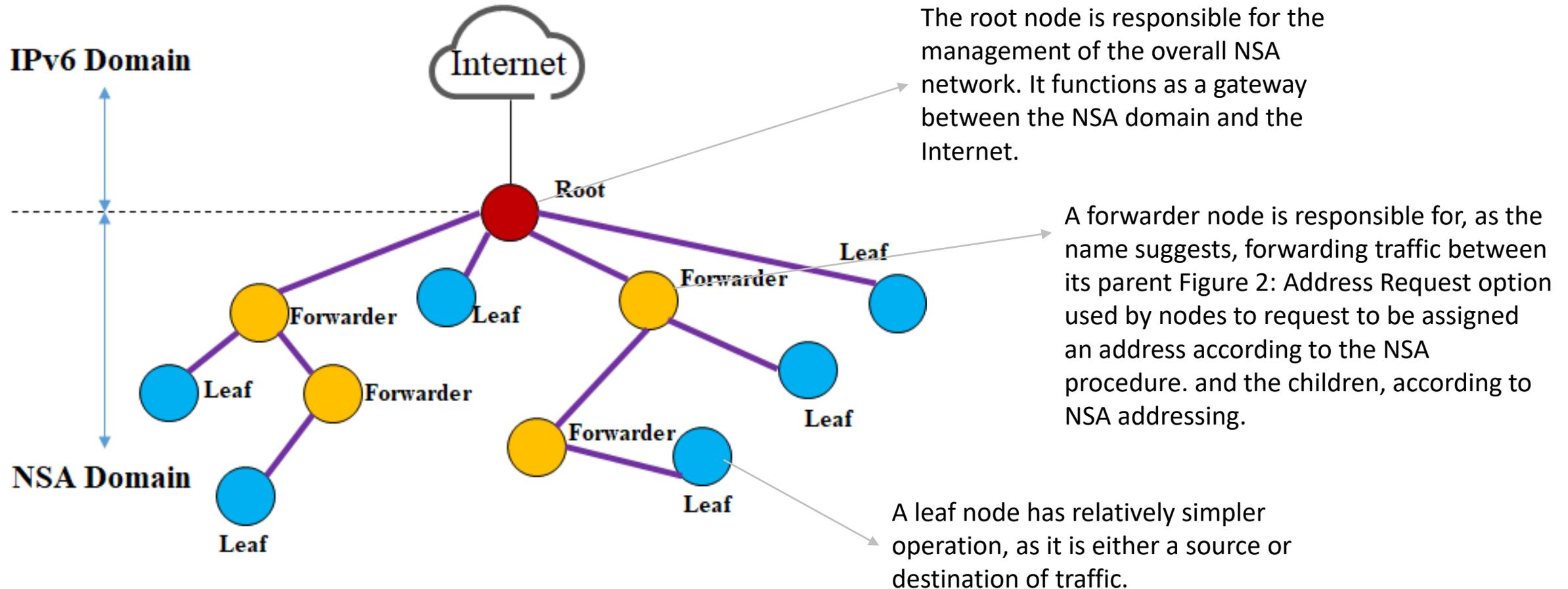
Motivation (to be updated)

- An ongoing massive expansion of the network edge that is driven by the "Internet of Things" (IoT) technology
- [SIXLOWPAN]/[SIXLO]/[LPWAN] WGs addresses many foundational issues for those type of deployments
- Existing solutions, however, may have some shortcomings:

Technology	Problem(especially in large scale LLN)
6lowpan-DHCPv6	Consume bandwidth and time before node working, by applying for address from centralized server through multiple hops
6lowpan-AutoConfig	Using large address space to reduce confliction, implicating longer address and larger routing table, thus limit scale of network
6lowpan-RH	RPL information causes extra overhead of packet. Routers consumes resource to advertise、store、manage routing table
6lowpan-IPHC	Context based address uncompressing consumes extra computing resource. 6lo-RPL(RFC 8138) avoids uncompressing hop-by-hop, however bring much more complexity in routing.

Simpler and more efficient addressing/routing/encapsulation exist based on but beyond previous work?

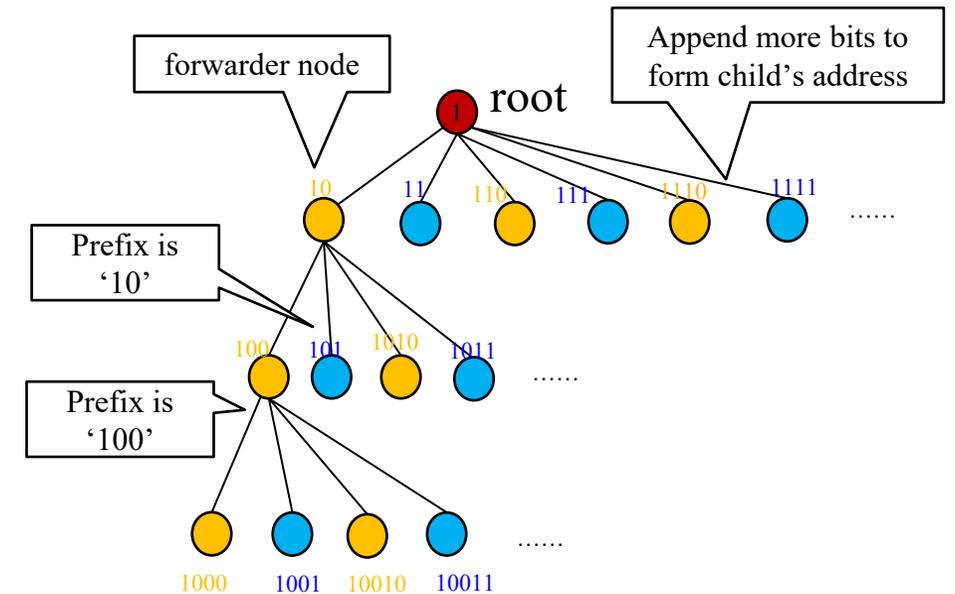
Native Short Addresses Architecture (NSA)



NSA Allocation

Algorithm consumptions:

- There are 3 roles for network nodes, **root/forwarder/leaf**.
- Root's address will always be '1', forwarder's address ends with '0', leaf's address ends with '1'.
- Normally, the root role is configured to border router before the LLN startup.
- All child nodes' address will start with their parent's address.



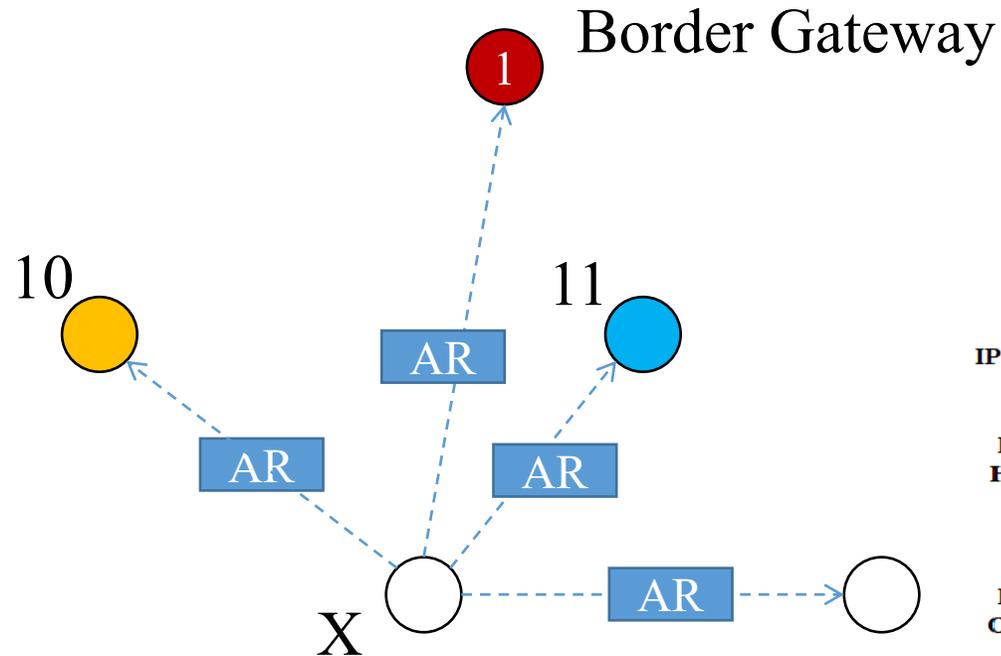
What does an example looks like

NSA Allocation core function is defined as:

```
A(role, i) = 'root/forwarder address'  
            + (i-1)*'1'  
            + (role == leaf?'1':'0'),  
in which, i is index of leaf/forwarder at this layer.
```

Figure 4: Definition of the allocation function of forwarder/root nodes.

Address Assignment Procedure - 01



Dispatch (indicators: NSA + TF + NH + HLIM)

I/O/M A Source Destination

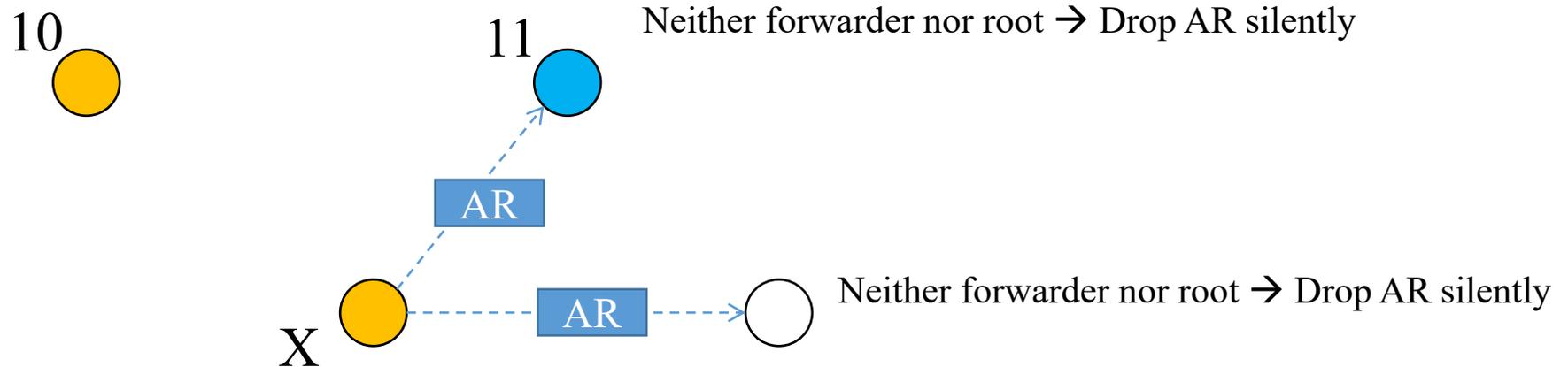
IP Header	0101	11	0	1	Payload Length = 24	1	0	Reserved	00000011
	00001111		NH=58			HLIM = 255			
ICMP Header	Type = 133		Code = 0		checksum				
	Reserved								
ICMP Options	Type = 136		Length = 1		Expected Address Lifetime = 0				
	L	Reserved							
	Type = 1		Length = 1						
Node-id = Link-Layer Address									

0000 0011: Unassigned Address
 0000 0111: All node address
 0000 1111: All routers address
 0001 1111: All leaves address

AR ({forwarder | leaf}, Nodeid=X)

Address Assignment Procedure - 02

1 Border Gateway



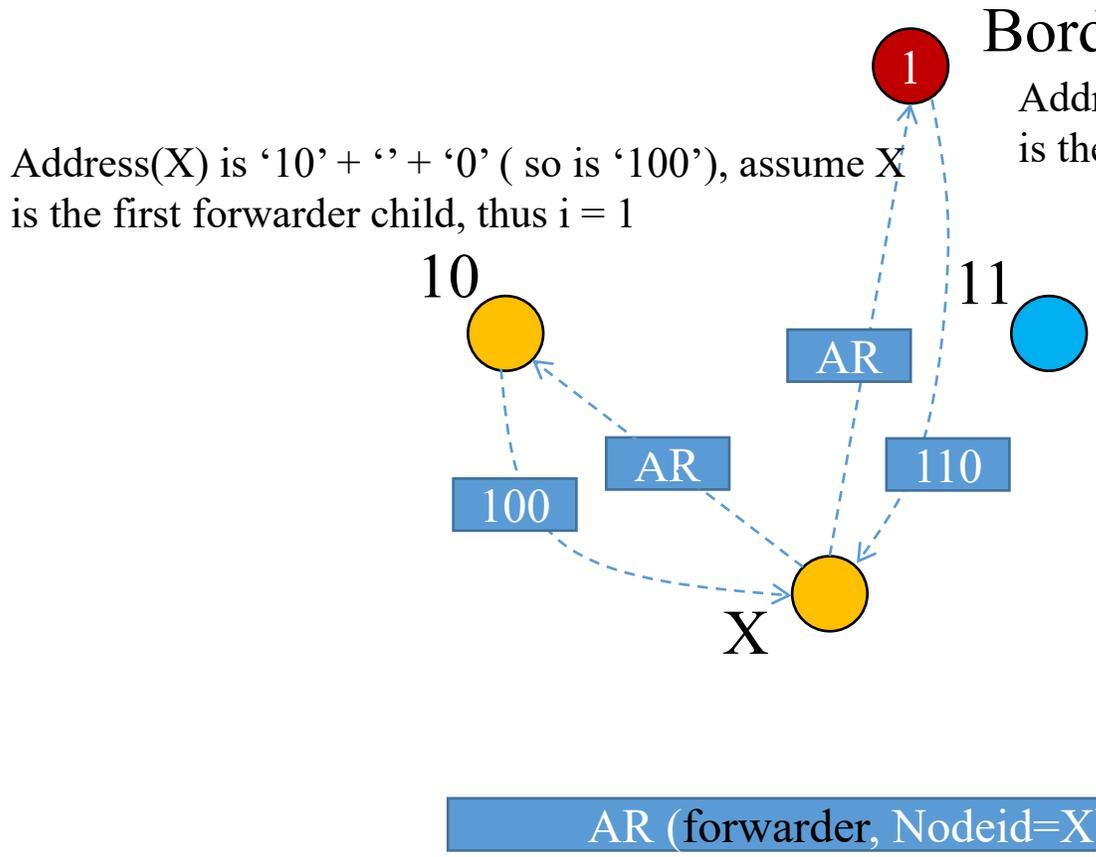
AR (forwarder, Nodeid=X)

Address Assignment Procedure - 03

```

A(role, i) = 'root/forwarder address'
            + (i-1)*'1'
            + (role == leaf?'1':'0'),
in which, i is index of leaf/forwarder at this layer.
    
```

Figure 4: Definition of the allocation function of forwarder/root nodes.

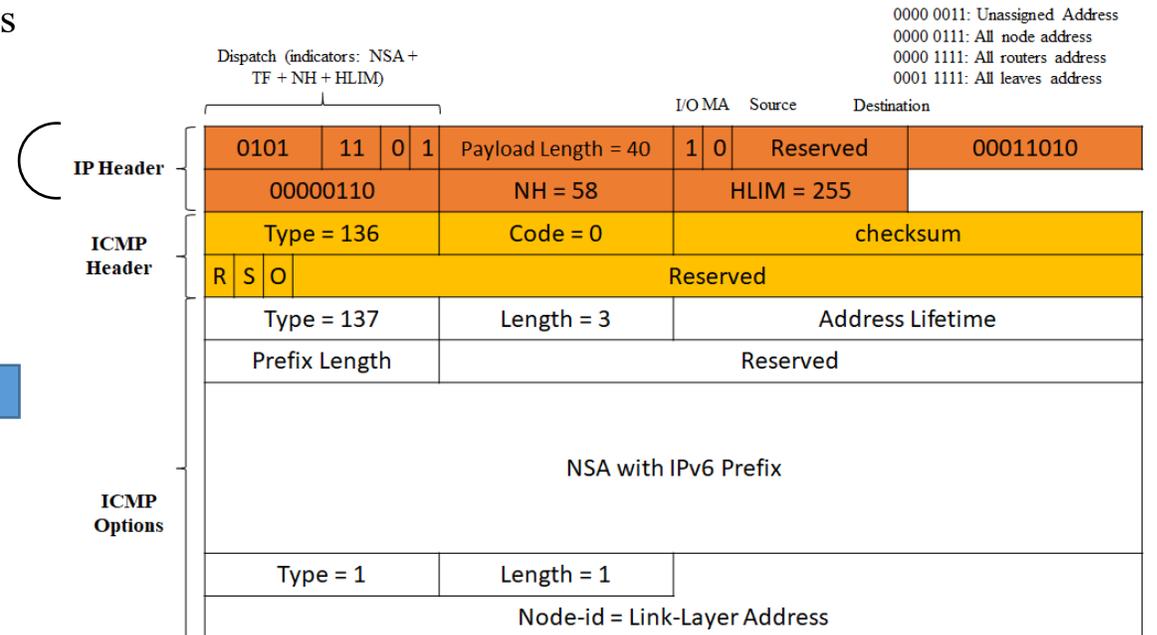
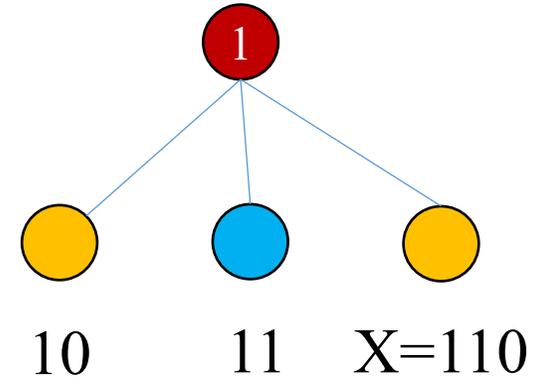
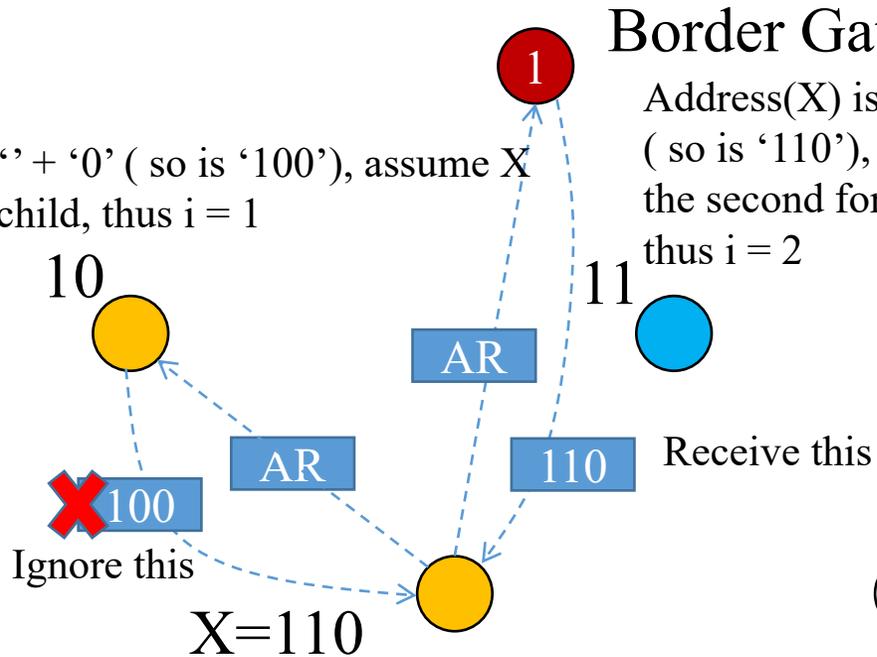


		Dispatch (indicators: NSA+ TF + NH + HLIM)				I/O MA		Source	Destination		
IP Header		0101	11	0	1	Payload Length = 40		1	0	Reserved	00000110
		00011010				NH = 58		HLIM = 255			
ICMP Header		Type = 134		Code = 0		checksum					
		Cur HLIM = 0		0	0	Reserved		Router Lifetime			
		Reachable Time									
		Retrans Timer									
ICMP Options		Type = 137		Length = 3		Address Lifetime					
		Prefix Length		Reserved							
		IPv6 Prefix									
		'0...0' + NSA									

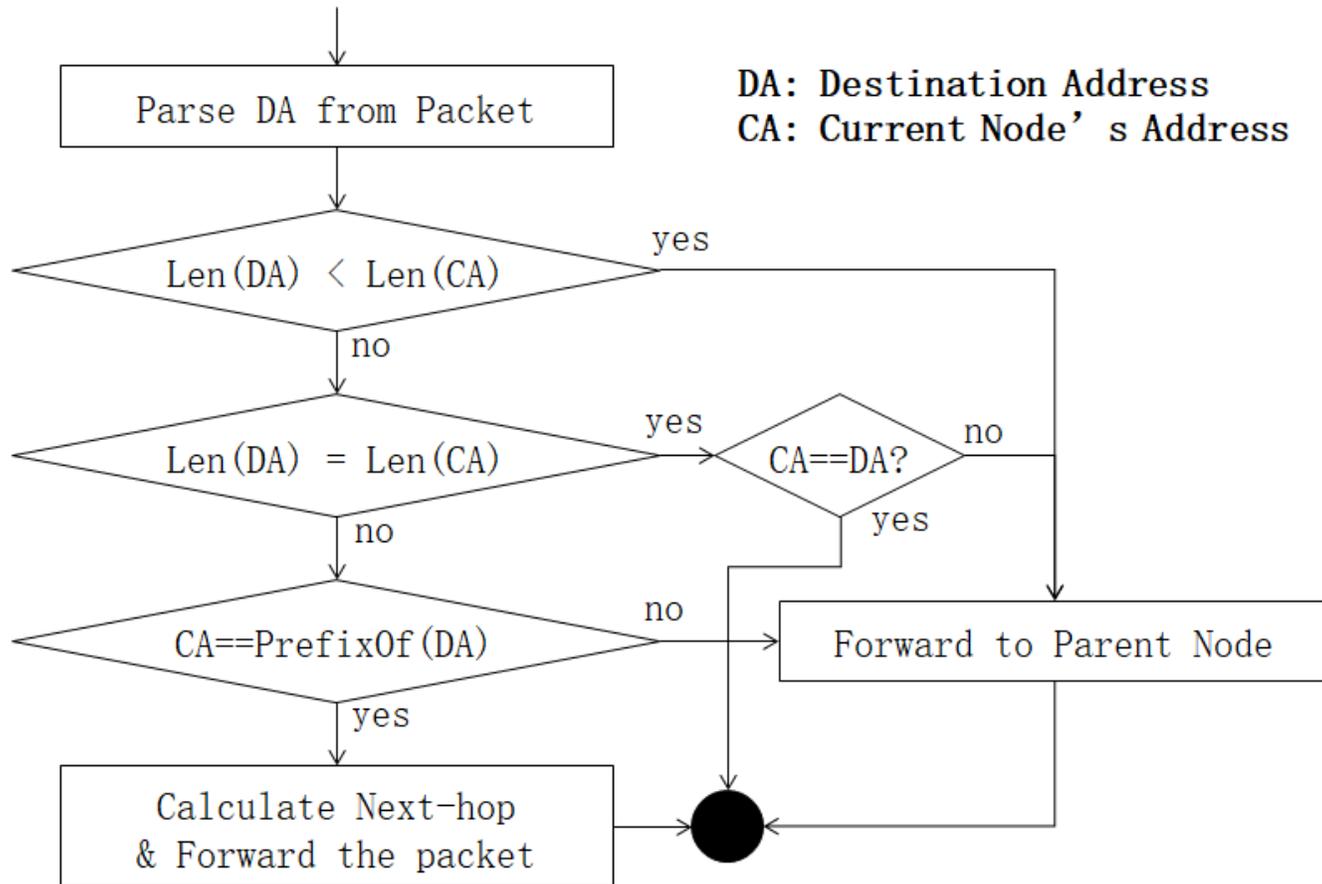
0000 0011: Unassigned Address
 0000 0111: All node address
 0000 1111: All routers address
 0001 1111: All leaves address

NSA Allocation (4)

Address(X) is '10' + '' + '0' (so is '100'), assume X is the first forwarder child, thus i = 1



Internal Stateless Forwarding



Rule 1: If the destination equals to current node's address, complete routing.

Rule 2: If current node is originating node and leaf, send packet to its parent;

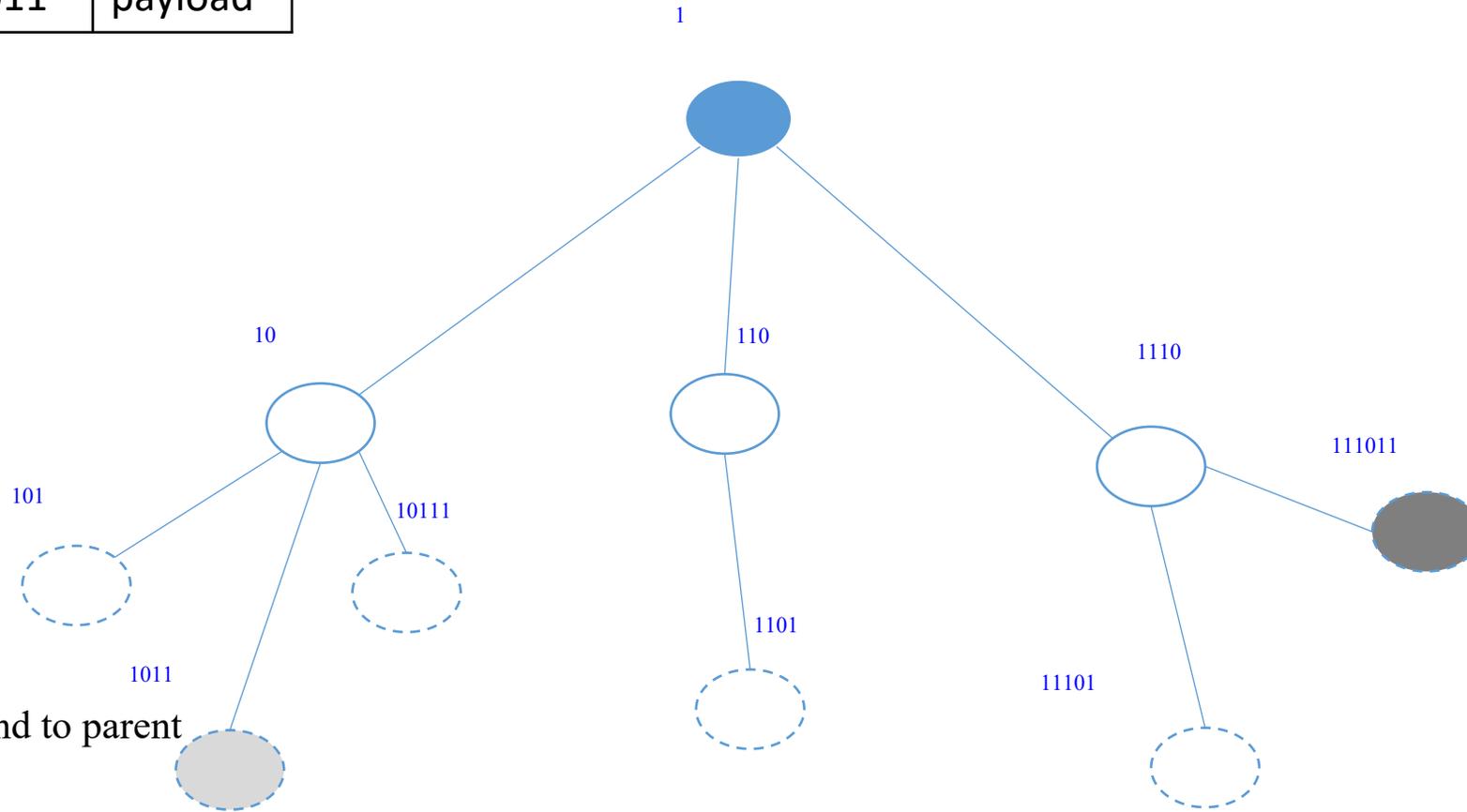
Rule 3: If current node is router and its address is prefix of DA(Destination Address), calculate next hop address. Check values from bits next to prefix, skip '1' until the first '0', to form a new longer prefix. This prefix should be direct child of current node.

Rule 4: If current node is not root, send packet to parent

Default Rule: drop and error report

Forwarding Example - 01

1011	111011	payload
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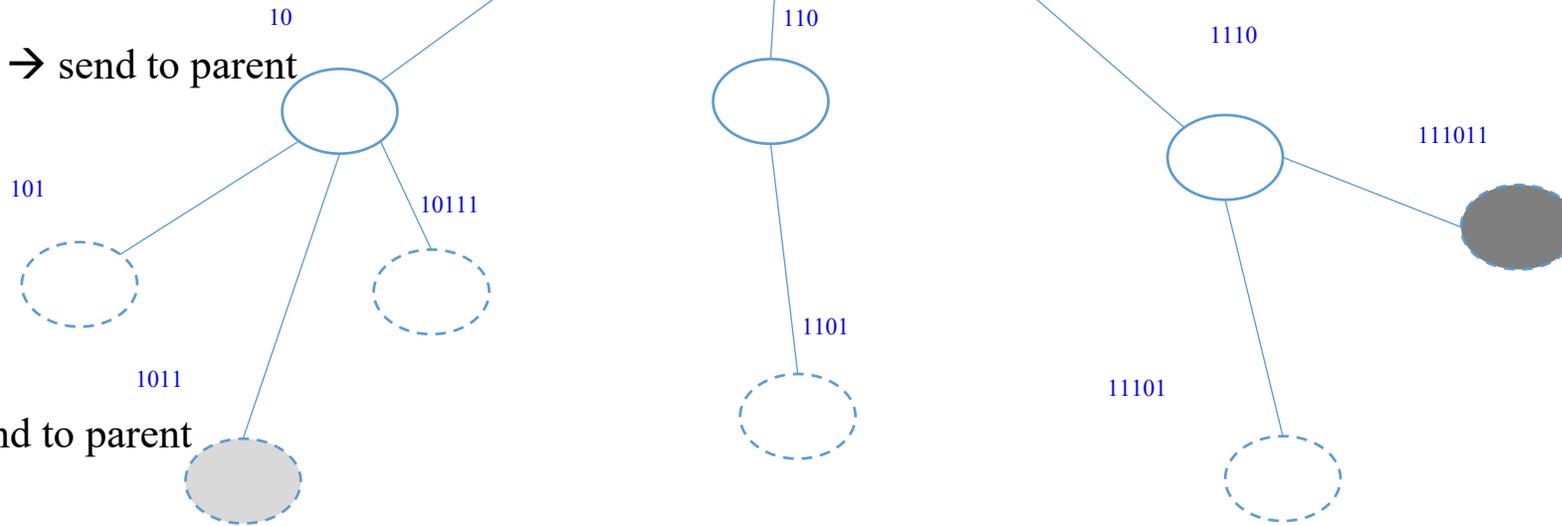
Rule 2: If current node is originating node and leaf,
send packet to its parent;

Forwarding Example - 02

1011	111011	payload
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Rule 4: If current node is not root,
send packet to parent

② rule 4 → send to parent

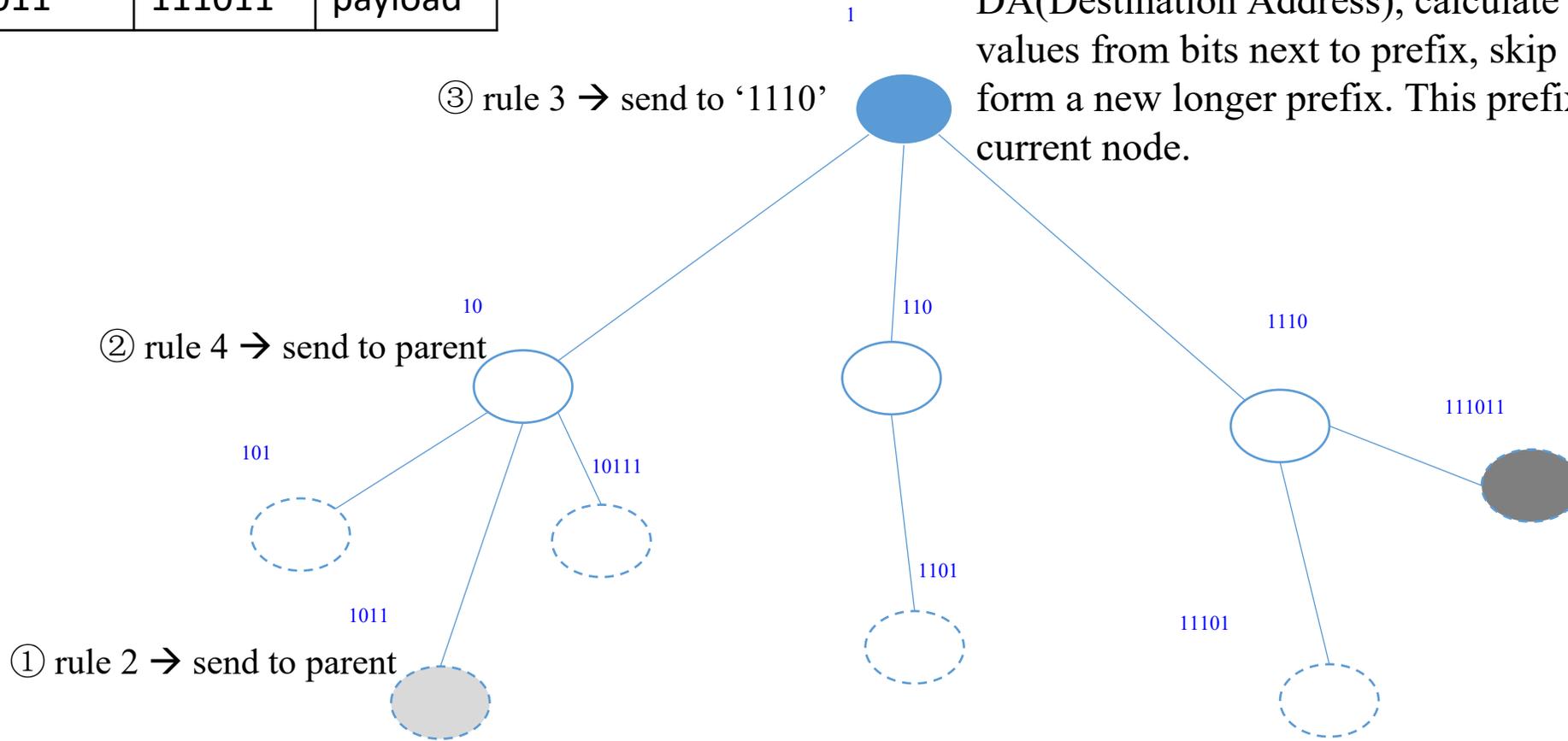


① rule 2 → send to parent

Forwarding Example - 03

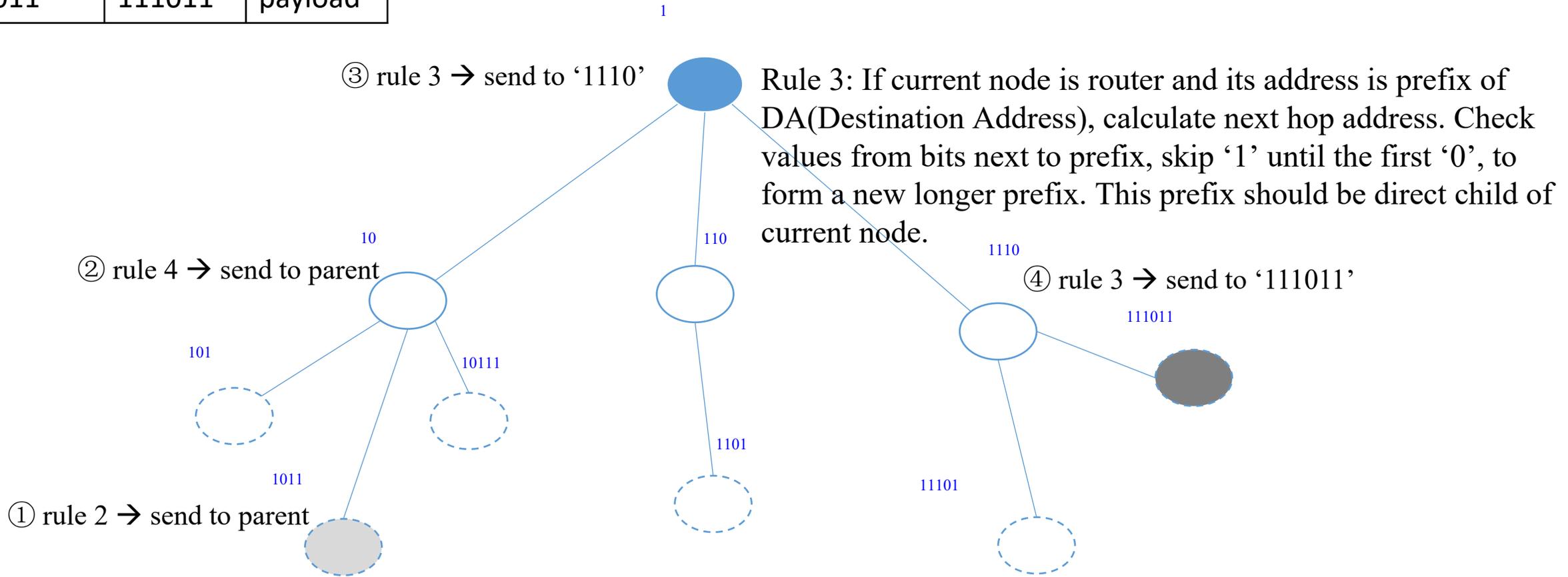
1011	111011	payload
------	--------	---------

Rule 3: If current node is router and its address is prefix of DA(Destination Address), calculate next hop address. Check values from bits next to prefix, skip '1' until the first '0', to form a new longer prefix. This prefix should be direct child of current node.



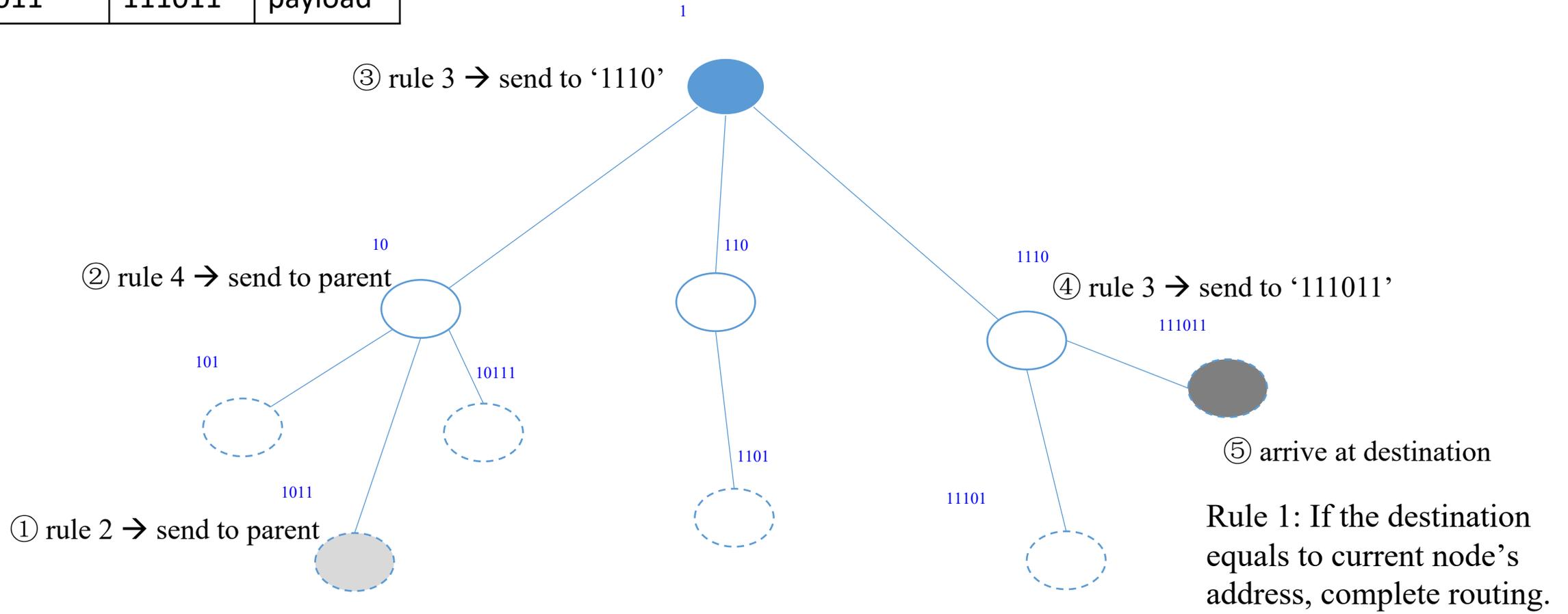
Forwarding Example - 04

1011	111011	payload
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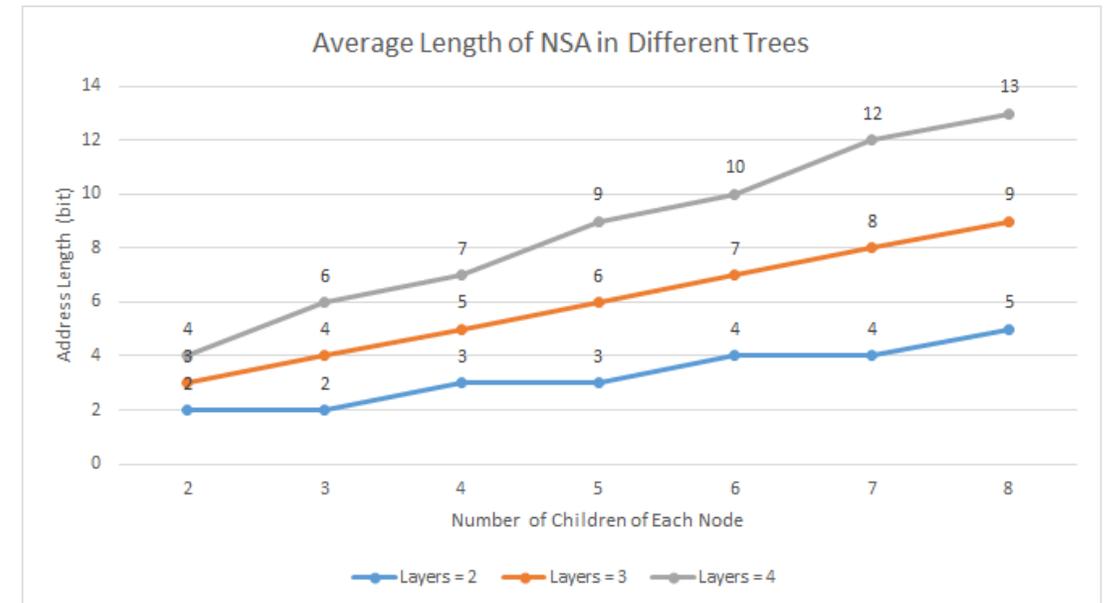
Forwarding Example - 05

1011	111011	payload
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Summary

- Native Short Addresses is a topological addressing scheme, suitable for IoT networks with relative stable connections.
- NSA achieves smaller average address length
- NSA enables stateless forwarding and is a greener solution
- NSA removes the need of defining the maximum number of child nodes in advance
- How to further improve the reliability of the system could be a future research topic



Thanks