MANET WG Overview

96th IETF Berlin 2016

Manet WG Chairs

What is MANET?

- Mobile Ad hoc Network
  - The vision: to support robust and efficient operation in mobile wireless networks by incorporating IP routing functionality into mobile nodes.
  - May operate in isolation, or may have gateways to and interface with a fixed network.
- Key Features of a MANET network
  - Dynamic topologies
  - Bandwidth-constrained wireless links
  - Energy-constrained operation
  - Limited physical security
  - Wireless interfaces

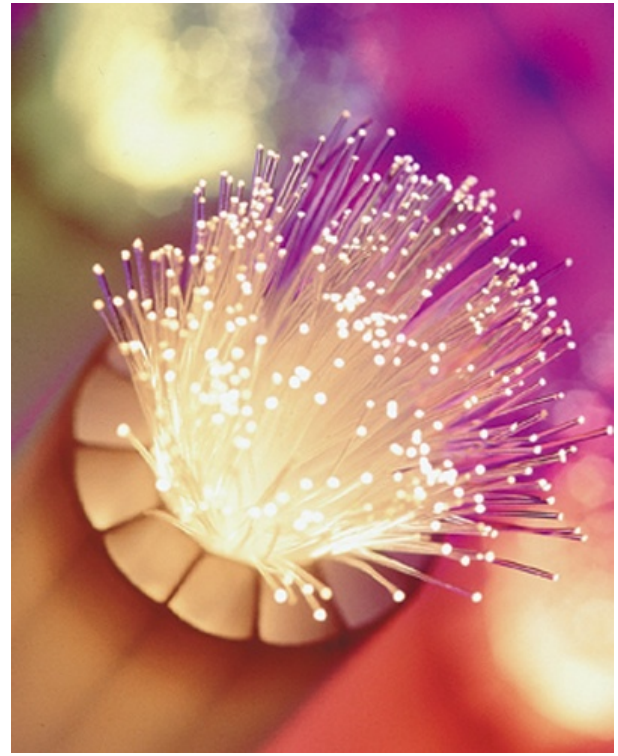
Wired vs. Wireless Overview

Traditional Network characteristics

Networks are based on high-speed links, with very low transmission error rates

Topology changes are relatively rare, and typically planned events

Strict hierarchical design is easy to enforce



Ad-hoc Network characteristics

- Low bandwidth, variable speed links
- Packet loss rates of 50% are common
- Rapid topology changes makes strict hierarchy impossible
- Network must function in harsh environmental conditions

Radio Types

Radio types

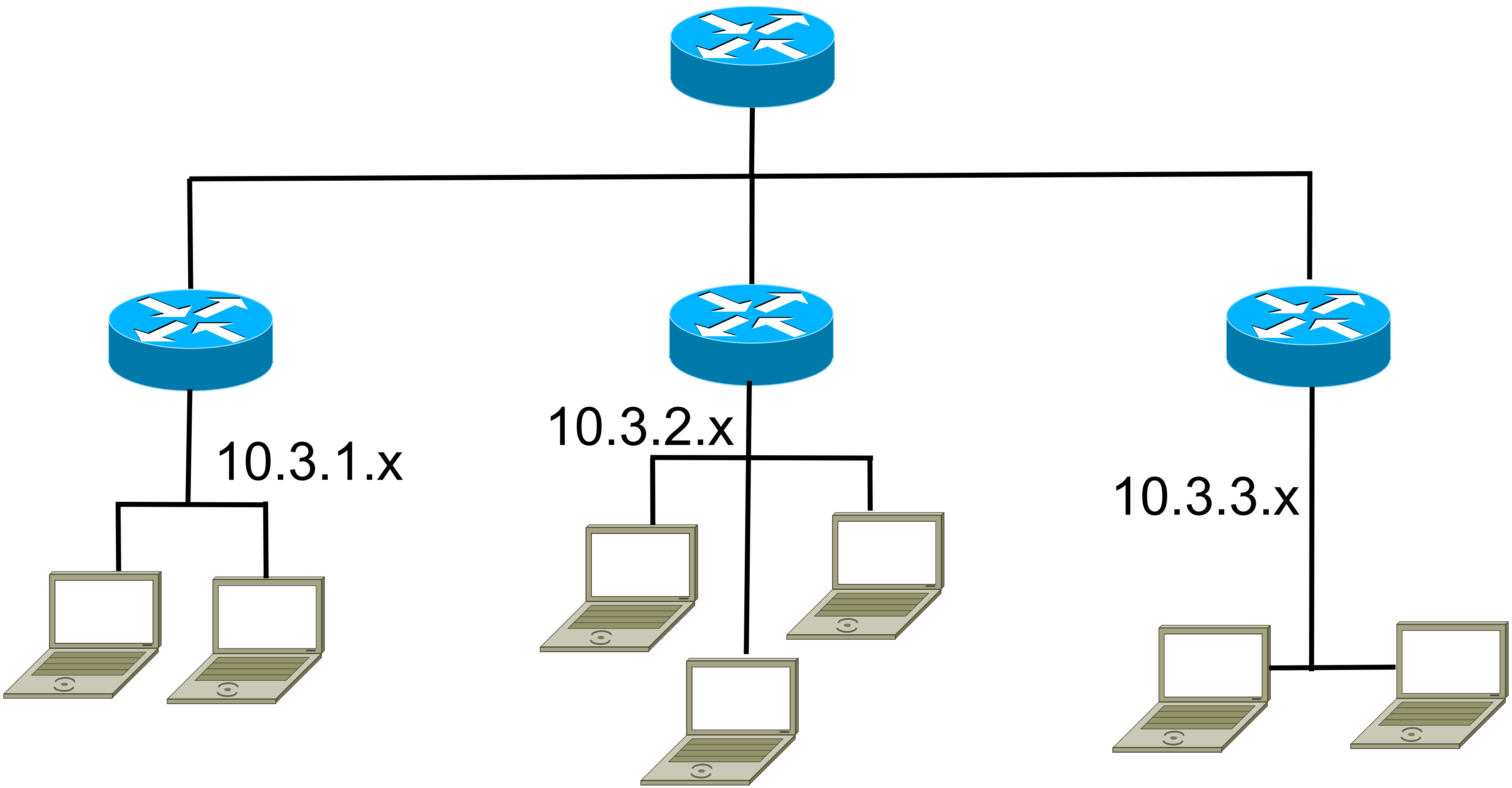
- Point-to-Point – These radios typically use TDMA; some also employ highly directional beams.
- Appear to a router as a single point-to-point link, or a collection of point-to-point links
- Use directional beams for better transmission length, and lower probability of detection/ interception
- Broadcast/multicast traffic must be replicated for physical transmission on all radio links

Radio types continued

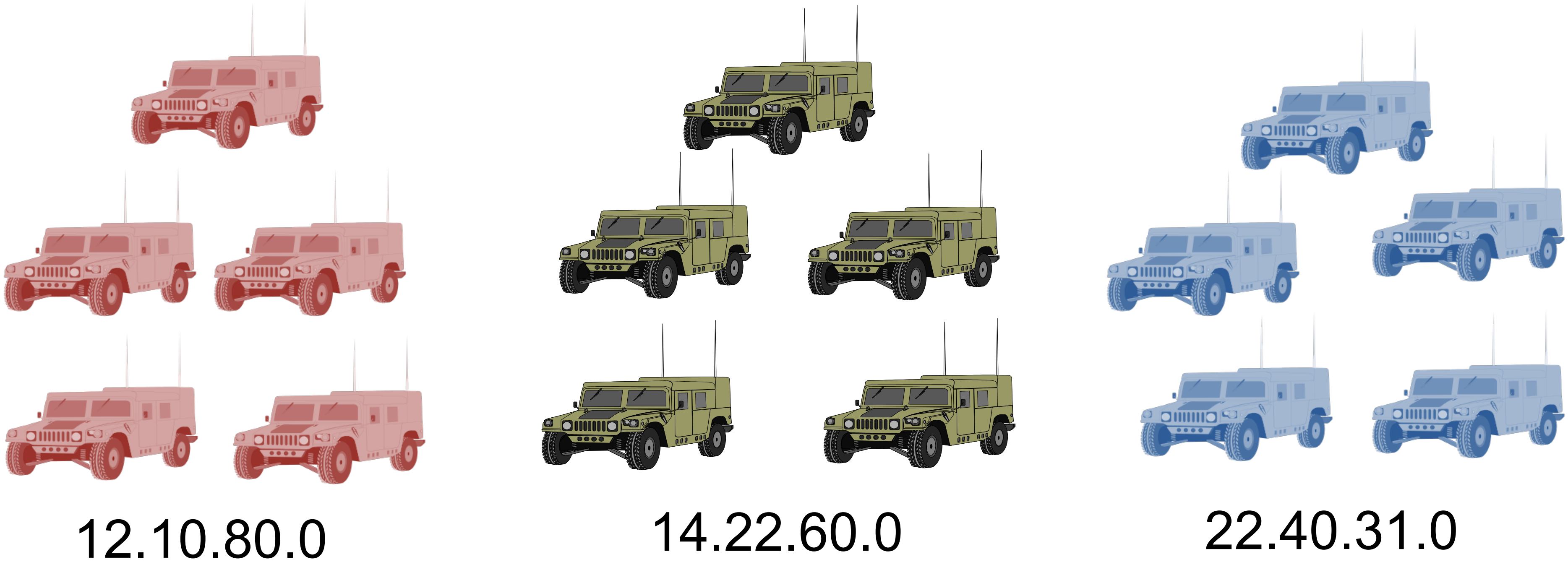
- Broadcast, Multi-Access radios
- At OSI Layer 2, these radios employ MAC protocols that are similar to Ethernet (e.g. 802.11)
- Base use case is omni-directional, broadcast/multicast transmission is accomplished with a single physical send.

Addressing

Wired Network Topology



Wireless addressing



Subnetting Doesn’t Work!!! (at least not well)

Other Addressing Issues

- Standard methods for auto-assigning non-duplicate addresses in a MANET do not exist
- Reacquiring addresses based on motion or location disrupts applications and causes security issues

IETF MANET Documents

RFCs

- RFC 2501 (issues and considerations)
- RFC 3561 (AODV)
- RFC 3626 (OLSR)
- RFC 3684 (TBRPF)
- RFC 4728 (DSR)
- RFC 5148 (Jitter)
- RFC 5444 (Packet Building Block)
- RFC 5497 (time tlv)
- RFC 5498 (IANA Allocations)
- RFC 6130 (NHDP)
- RFC 6621 (SMF)
- RFC 6622 (packetbb integrity check)
- RFC 6779 (NHDP MIB)
- RFC 7181 (OLSRv2)
- RFC 7182 (updated packetbb integrity check)
- RFC 7183 (OLSRv2 use of sec)
- RFC 7184 (OLSRv2 MIB)
- RFC 7185 (OLSRv2 metric rational)
- RFC 7186 (NHDP sec threats)
- RFC 7187 (OLSRv2 optimization)
- RFC 7188 (OLSRv2/NHDP updates on TLV processing)
- RFC 7367 (SMF MIB)
- RFC 7466 (NHDP optimization)
- RFC 7631 (TLV naming)
- RFC 7722 (OLSRv2 multitopology)
- RFC 7779 (DAT metric)
- RFC 7859 (identiy based signatures)

First Generation Experimental Protocols

pe

- ast Forwarding (SMF)
- OLSRv2 sec threats
- OLSRv2 multipath
- Dynamic Link Exchange Protocol
- Credit window extension for DLEP

Dead

- AODVv2

Near term deliverables

- Manet Management and deployment
- DLEP extentions
- Multicast Forwarding Information Base

MANET Brief History

MANET Start
~1997-2007

- 2 Experimental Proactive Protocols
- 2 Exp Reactive

MANET Reboot

2005-2016

- 1 standard Proactive
- 1 standard Reactive

Building Block Approach

2006-2011

- Packet format
- Neighbor discovery
- Protocols
- Generalized multicast

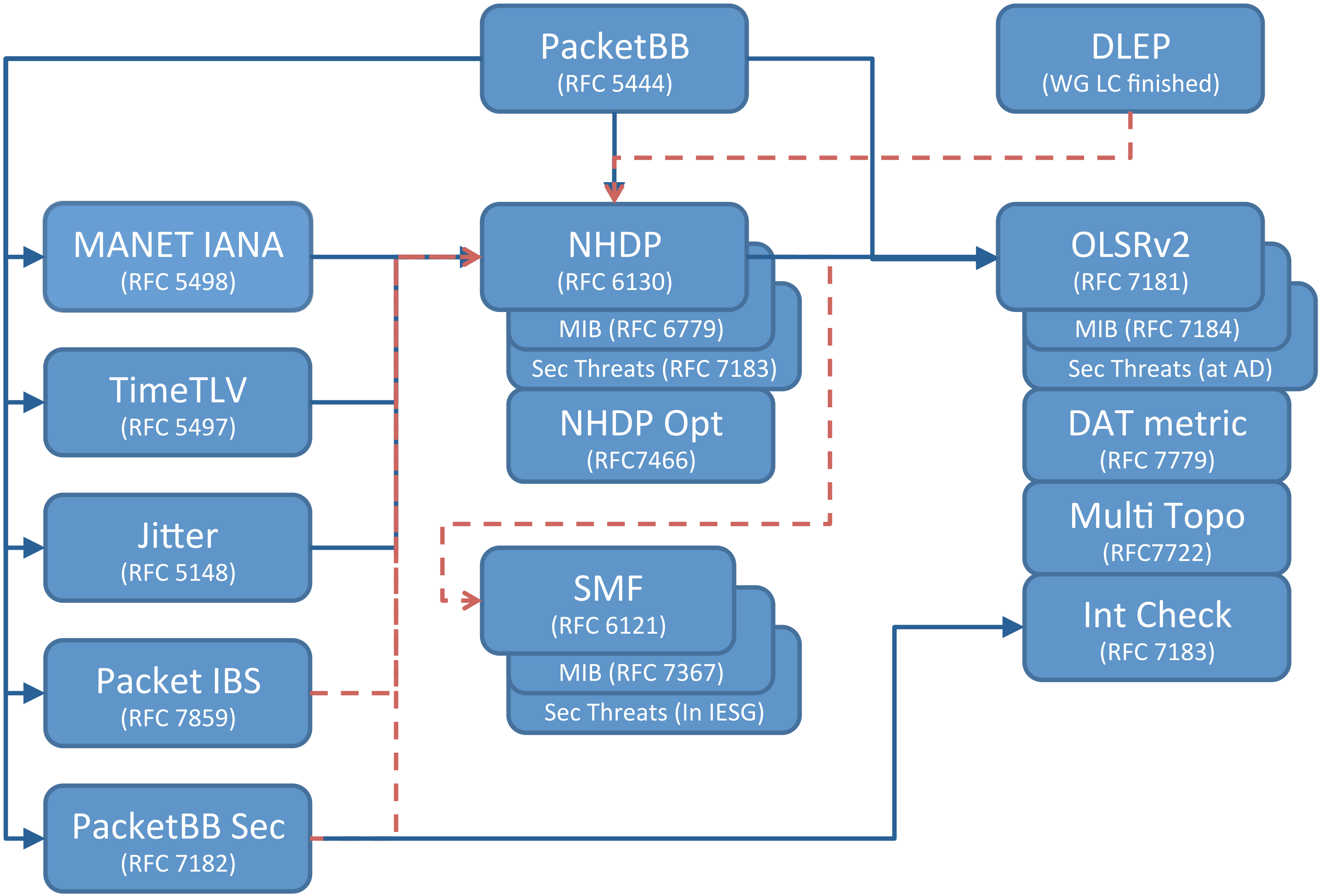
Extensions
2007-current

- Time
- Security
- Protocol Improvements

Today
2010-current

- Radio/Router Interface
- Multicast building block approach

IETF MANET Document Structure Overview

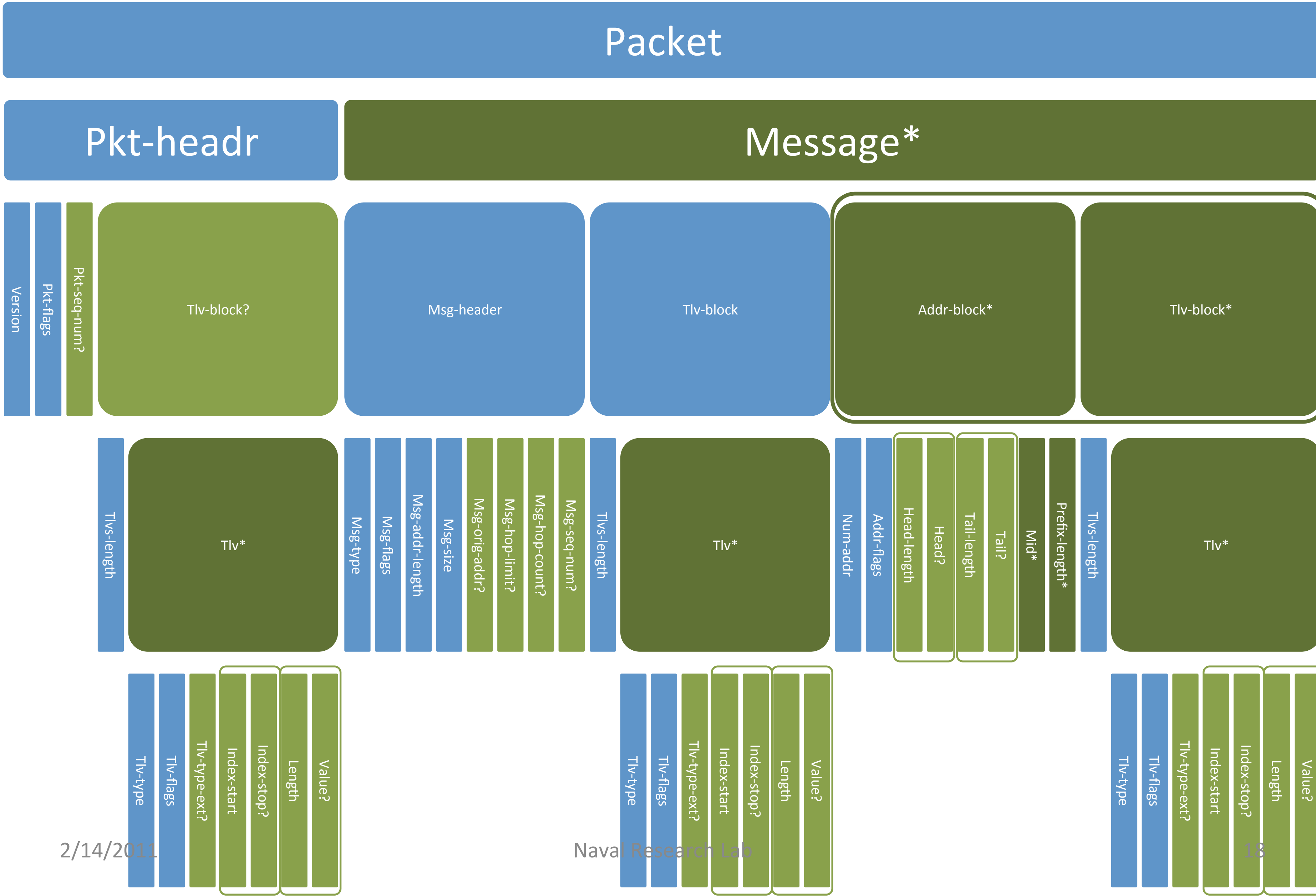


Packet Building Block (Packetbb)
RFC 5444 Overview

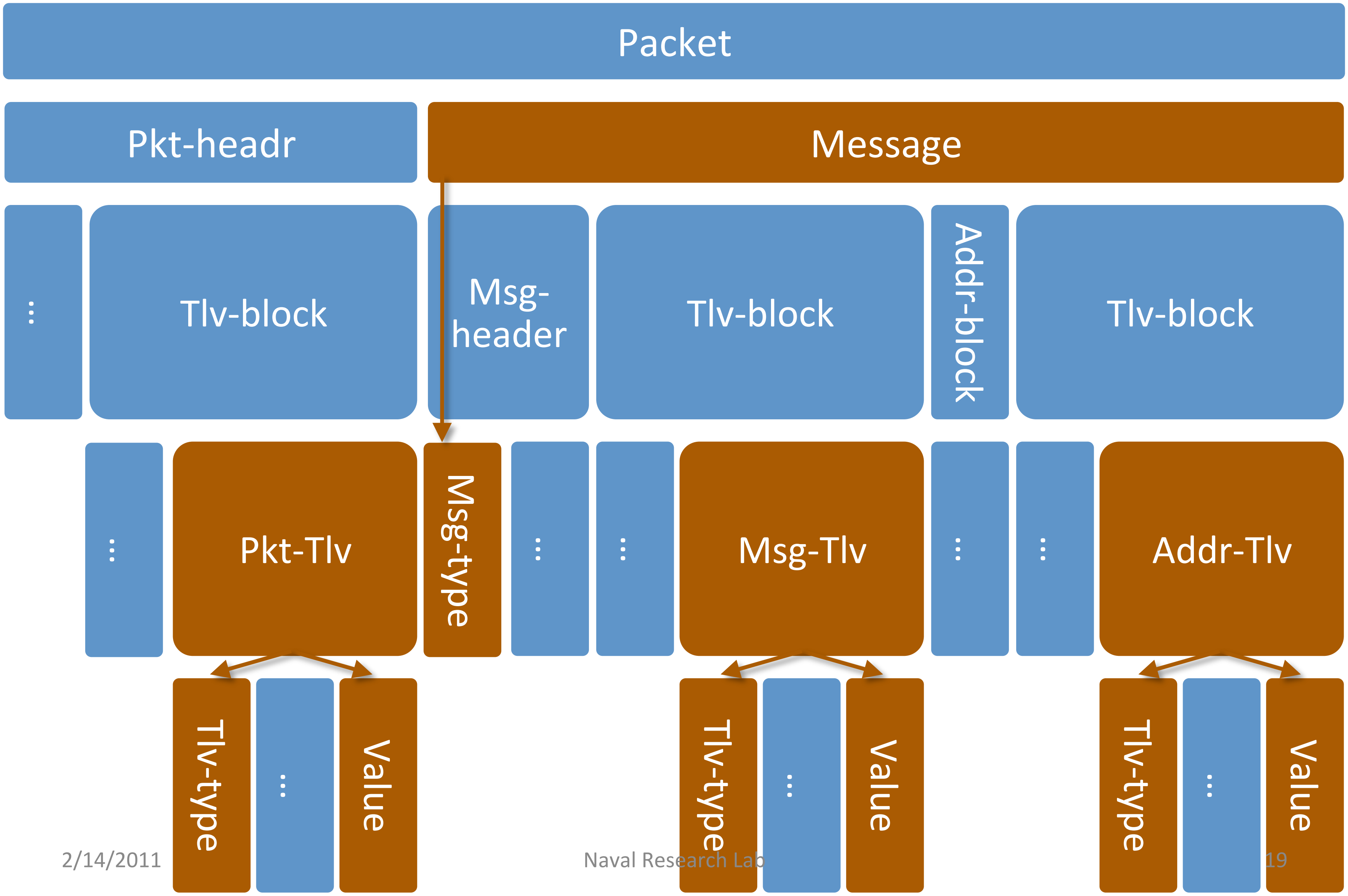
What is Packetbb? RFC 5444

- Packet Building Block
  - a packet format designed for carrying multiple routing protocol messages for information exchange between MANET routers
- Key Features of Packetbb
  - Multiple messages per packet
  - Extensible via Type Length Value fields
    - Packet TLV
    - Message TLV
    - Address TLV
  - Compression
    - Address compression
    - TLV compression
  - Multiplexer for multi protocol operation

Packet Building Block (RFC 5444) Structure



Packet Building Block (RFC 5444) Usage



Packet Building Block

RFC5444

- Simple Example

```
,------------------
|  PACKET
|------------------
| * Packet version:                  0
| * Packet flags:                    0
|    ,-------------------
|    |  MESSAGE
|    |-------------------
|    | * Message type:               7
|    | * Message addr. length:       4
|    | * Message flags:              0
|    `-------------------
|
`------------------
```

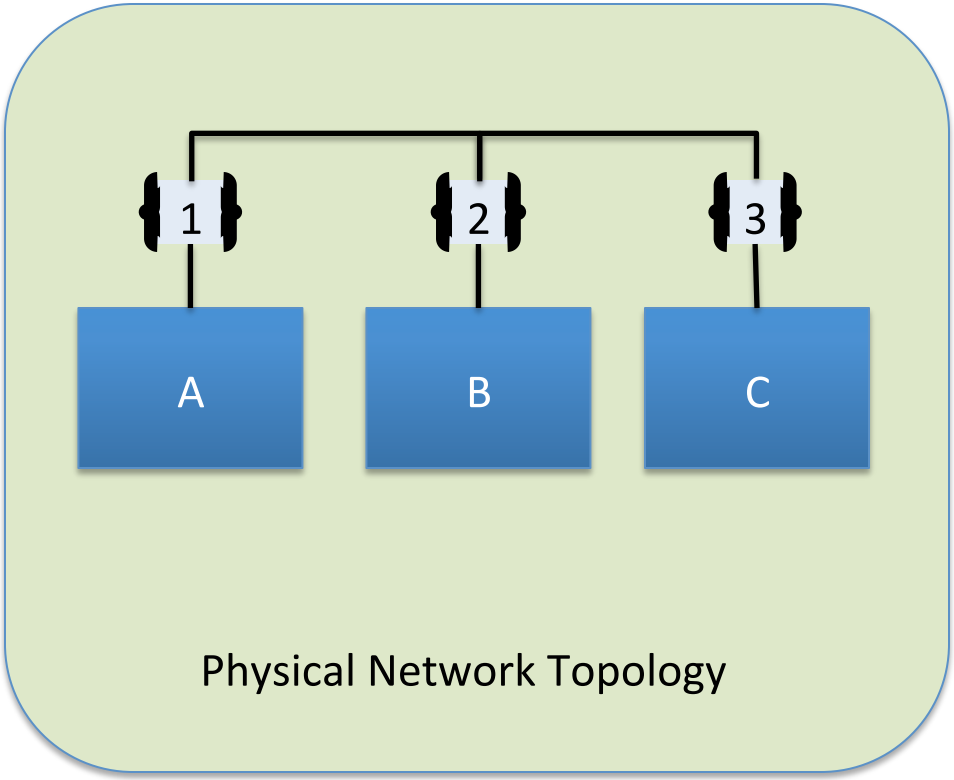
```
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 0 0|  Msg type=7   |0 0 0 0 0 0 1 1|           Leng|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|th=6           |      Tlv Block Length=0       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

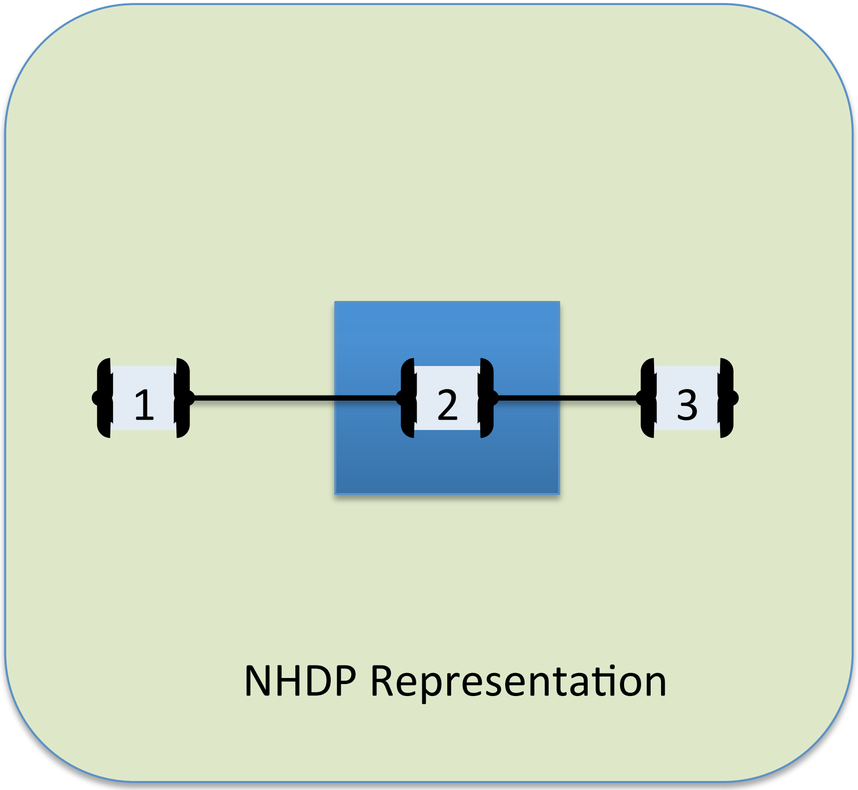
Neighborhood Discovery Protocol (NHDP)
RFC 6130 Overview

What is Neighborhood Discovery Protocol (NHDP/RFC 6130)?

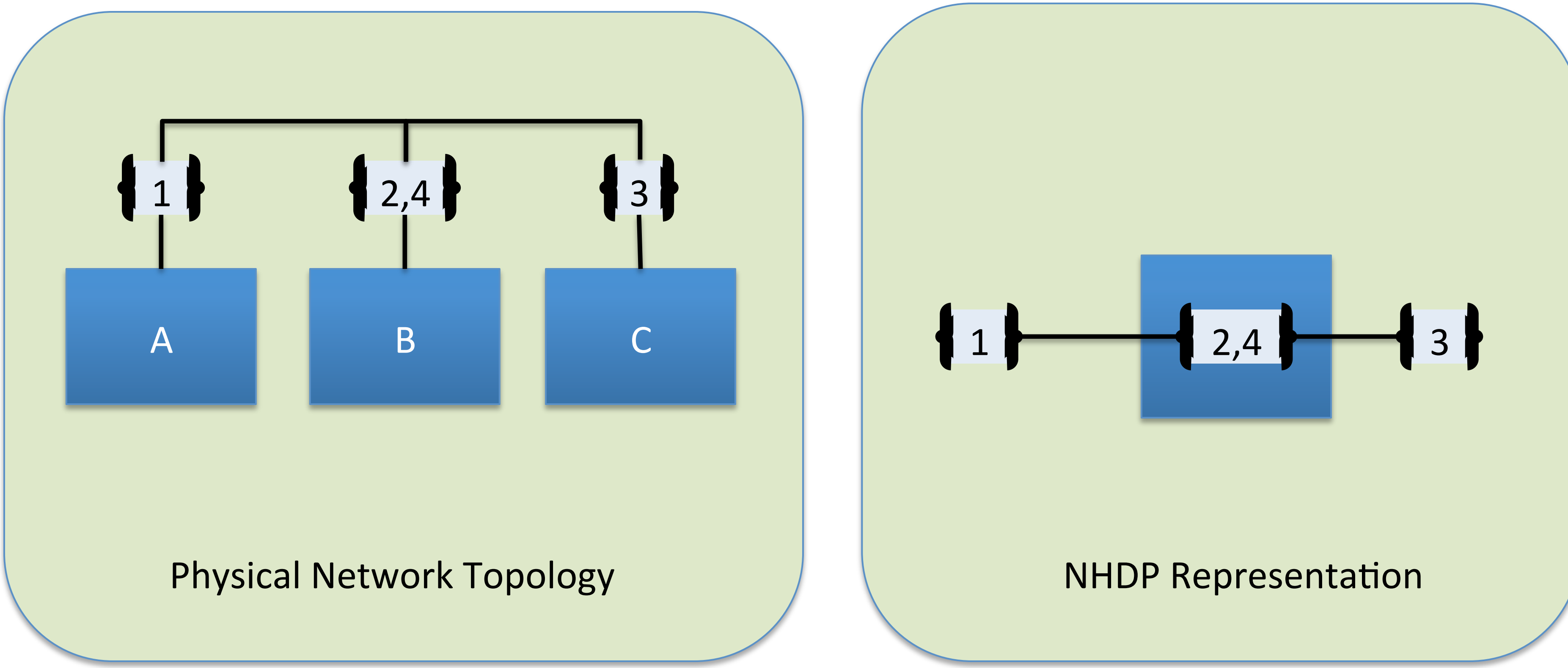
- Neighborhood Discovery Protocol
  - Uses local exchange of HELLO messages so that each router can determine the presence of, and connectivity to, its 1-hop and symmetric 2-hop neighbors
- Key Features of NHDP
  - Uses RFC 5444
    - Extendable
    - Can use commonly defined TLVs
  - Hello based discovery
    - Discovers one and two hop neighbor information
    - Discovers Symmetry
    - Supports metrics
    - Dynamic timers
  - Provides information bases for use of other protocols
  - Multiple interface support

NHDP Example 1
Standard Single Interface Topology

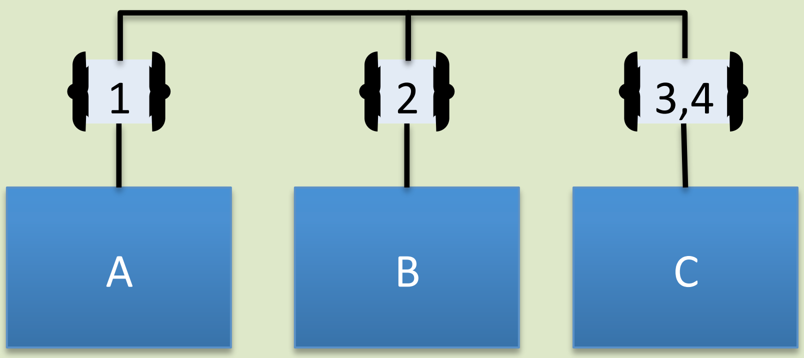




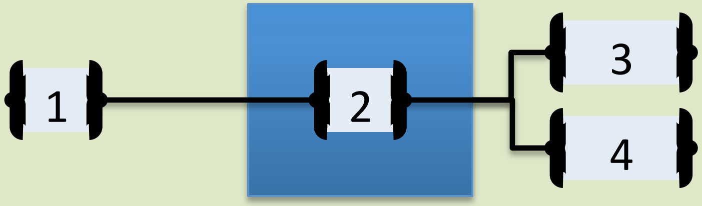
NHDP Example 2
Dual Addressed Iface on 1-Hop Neighbor



NHDP Example 3
Dual Addressed Iface on 2-Hop Neighbor

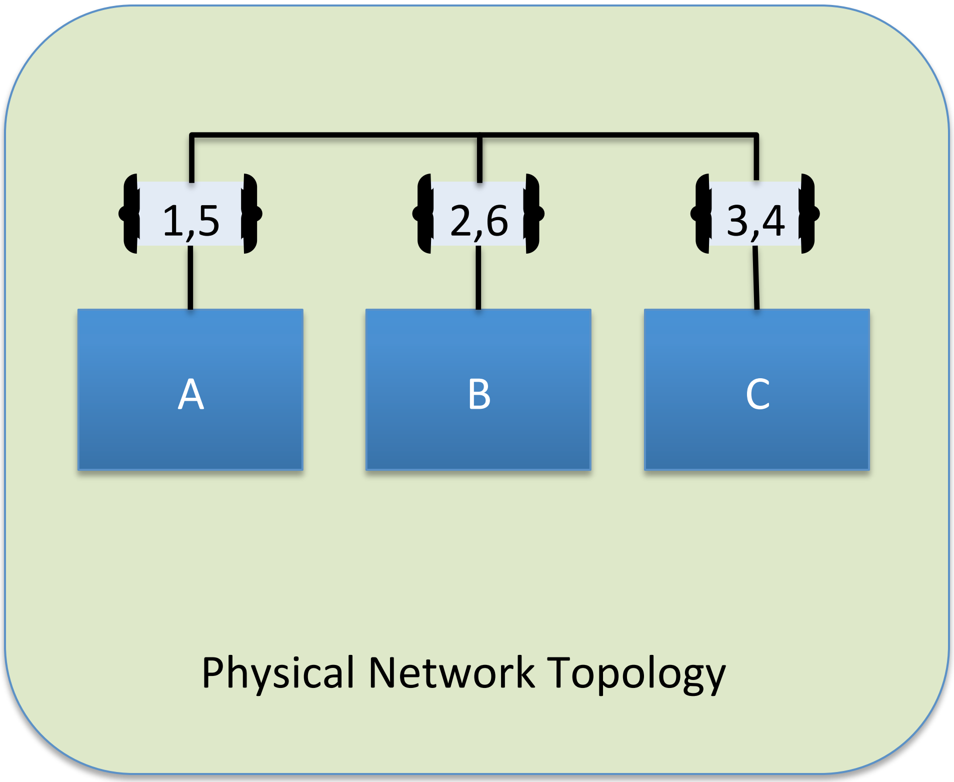


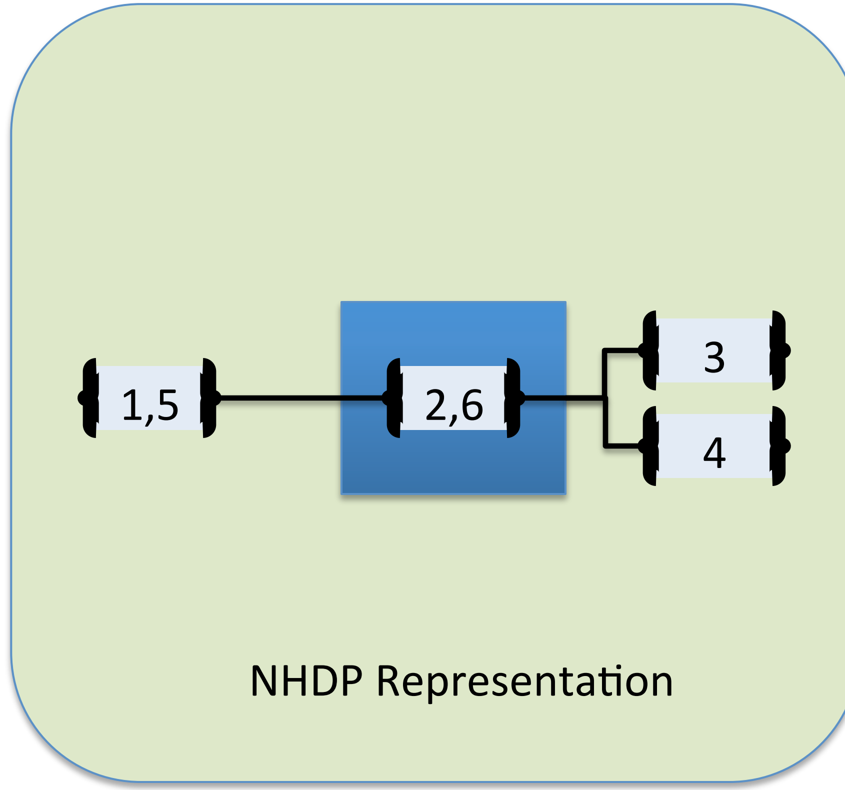
Physical Network Topology



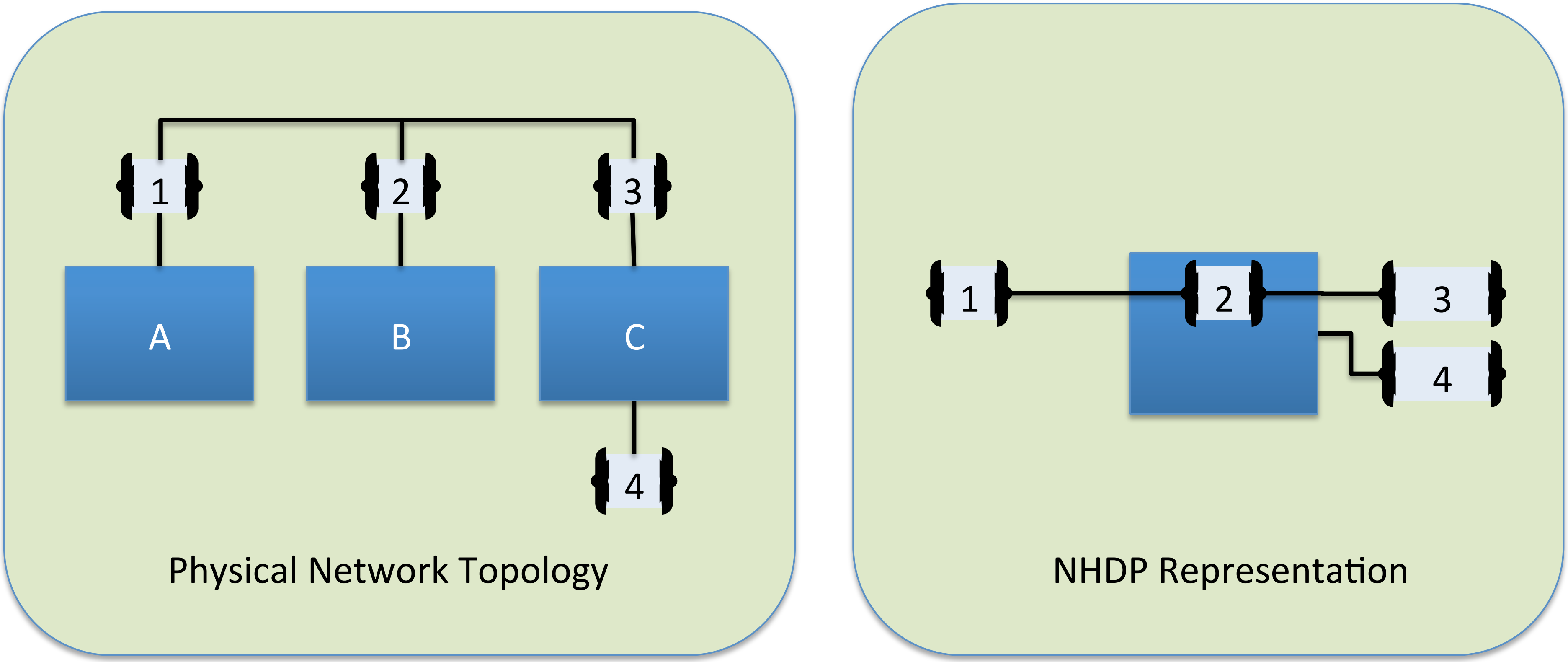
NHDP Representation

NHDP Example 4
Dual Addressed Interfaces

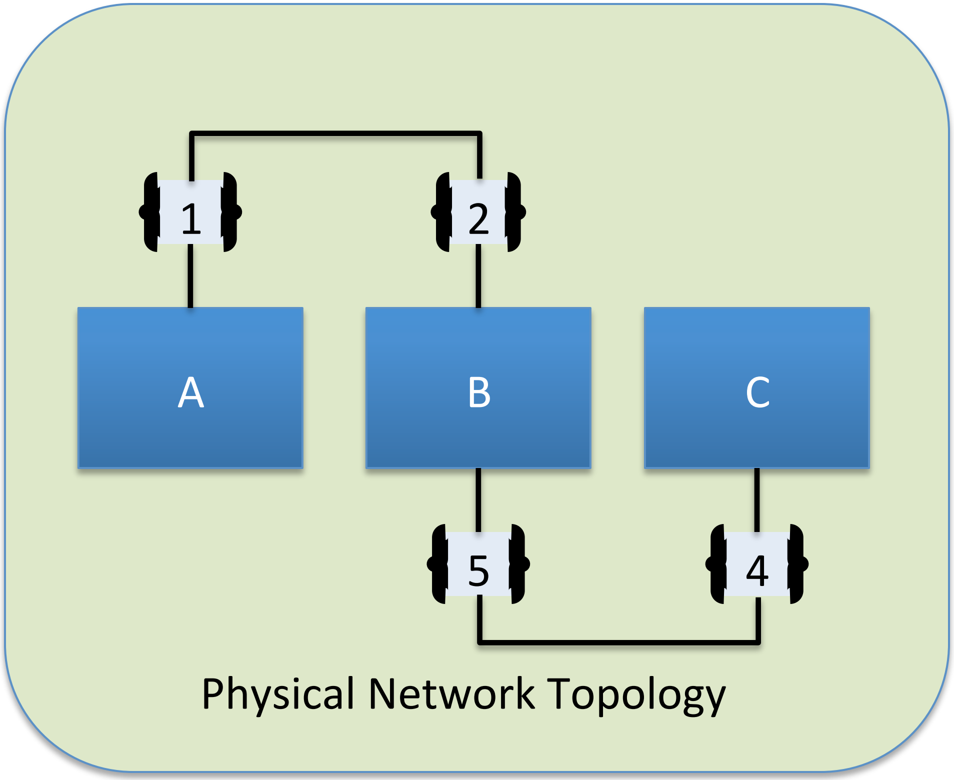


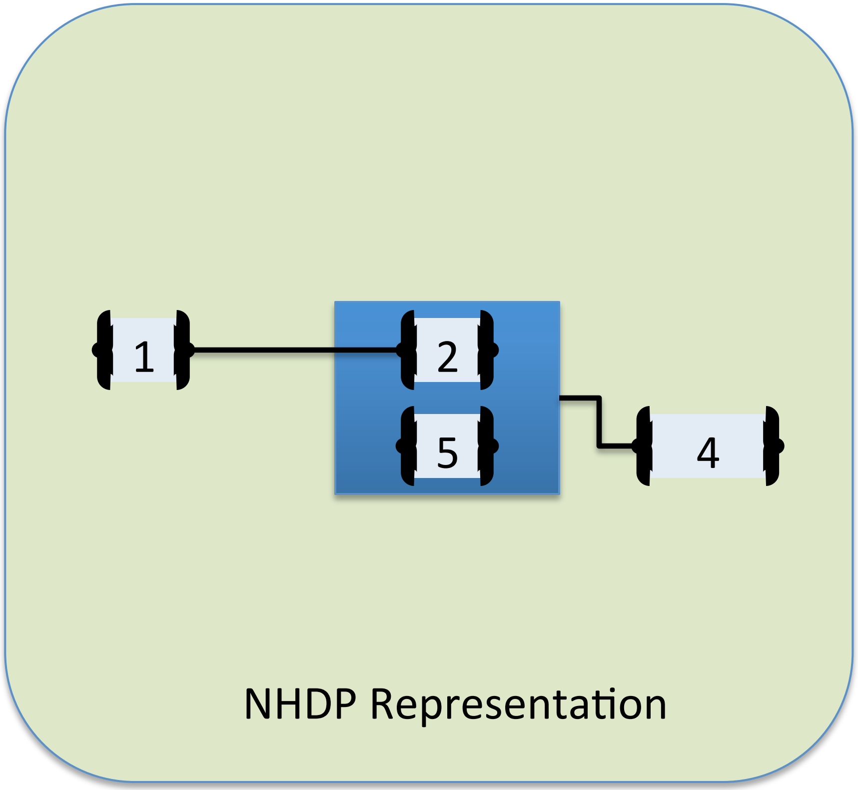


NHDP Example 5
Dual Interface on 2-Hop Neighbor

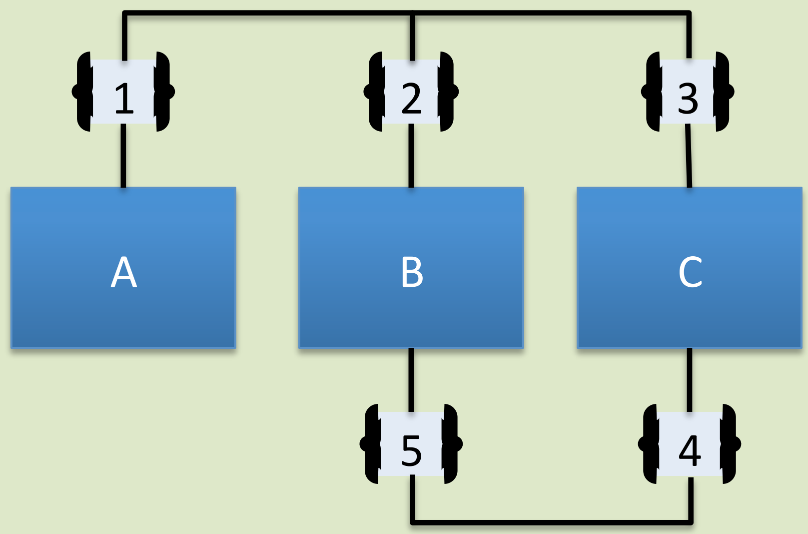


NHDP Example 6
Dual interface on 1-Hop Neighbor

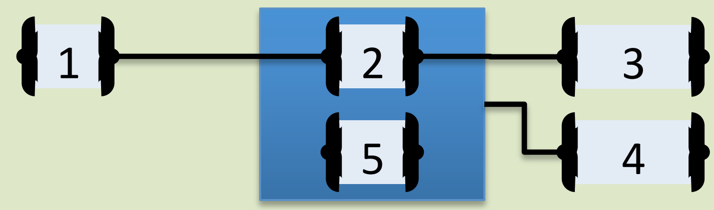




NHDP Example 7
Dual Iface on 1-Hop and 2-Hop Neighbors

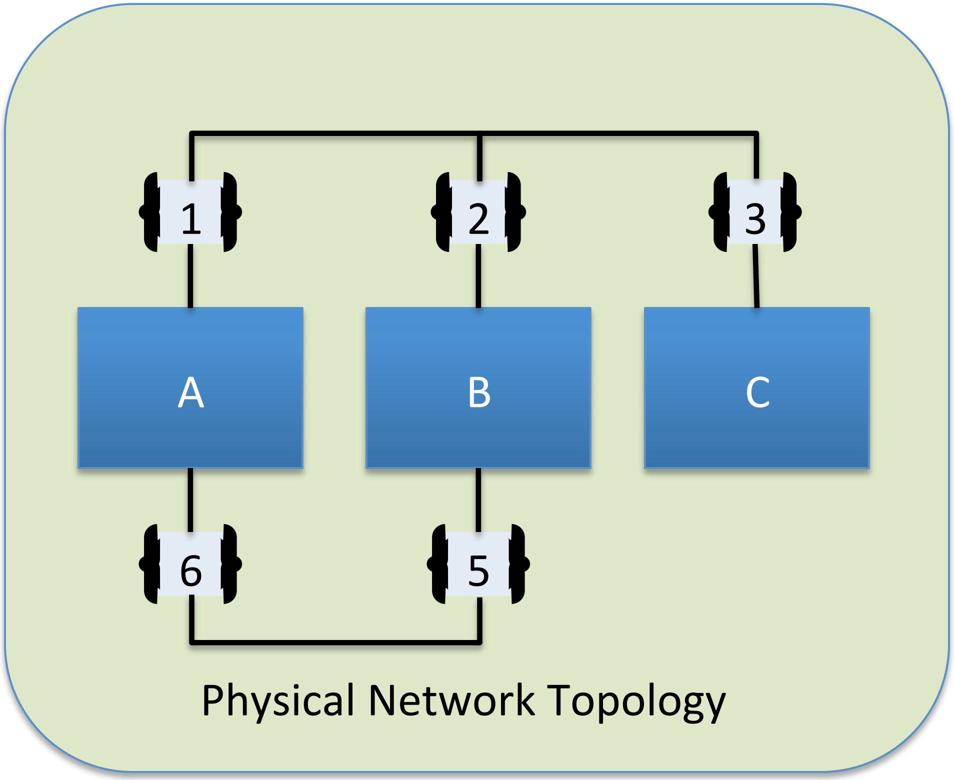


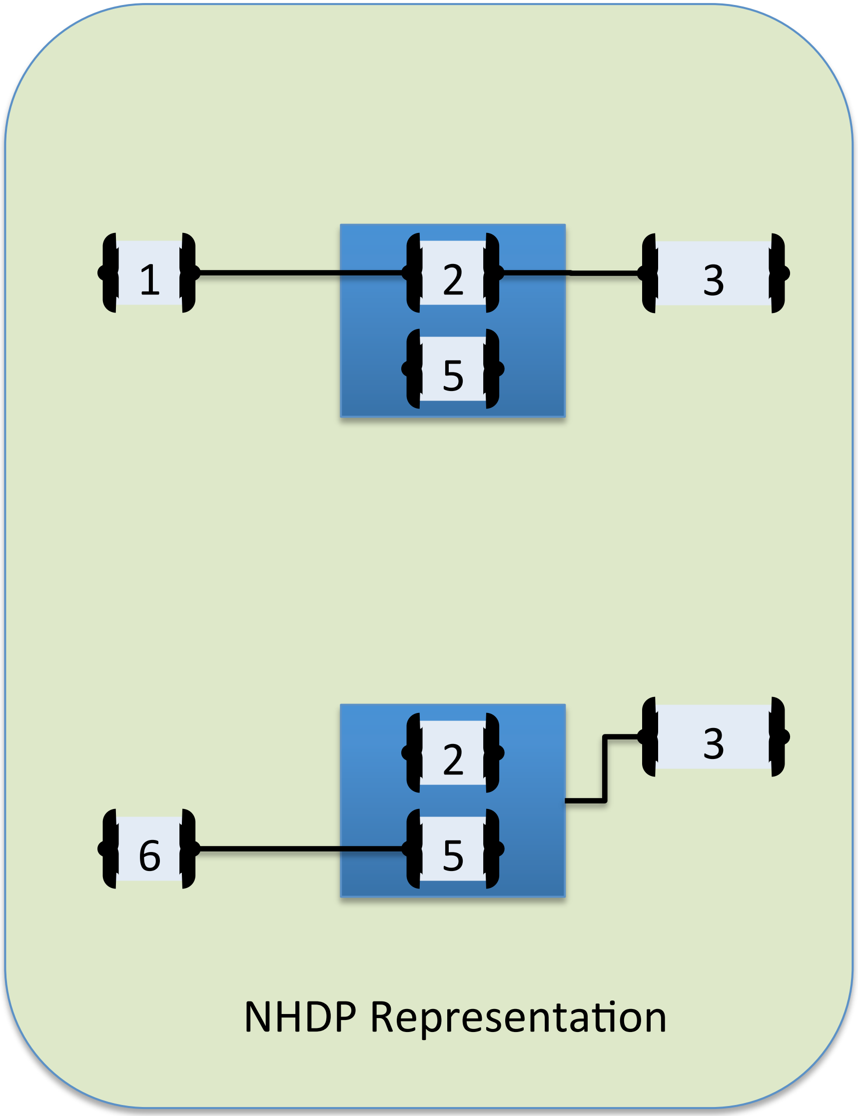
Physical Network Topology



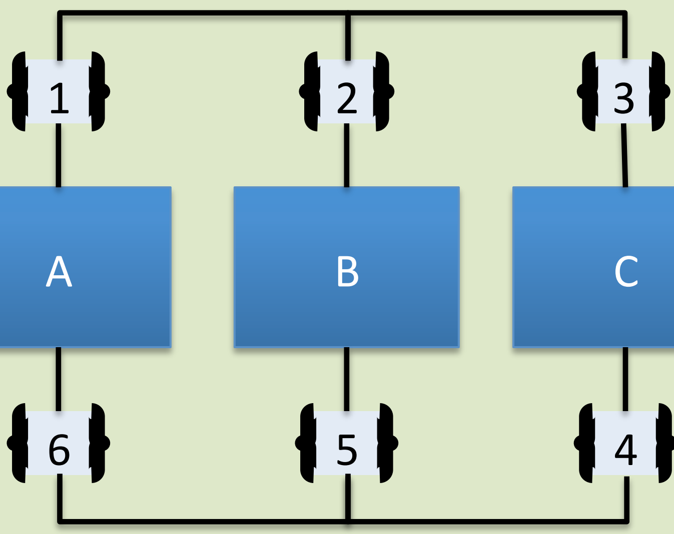
NHDP Representation

NHDP Example 8
Dual Iface Locally and on 1-Hop Neighbor

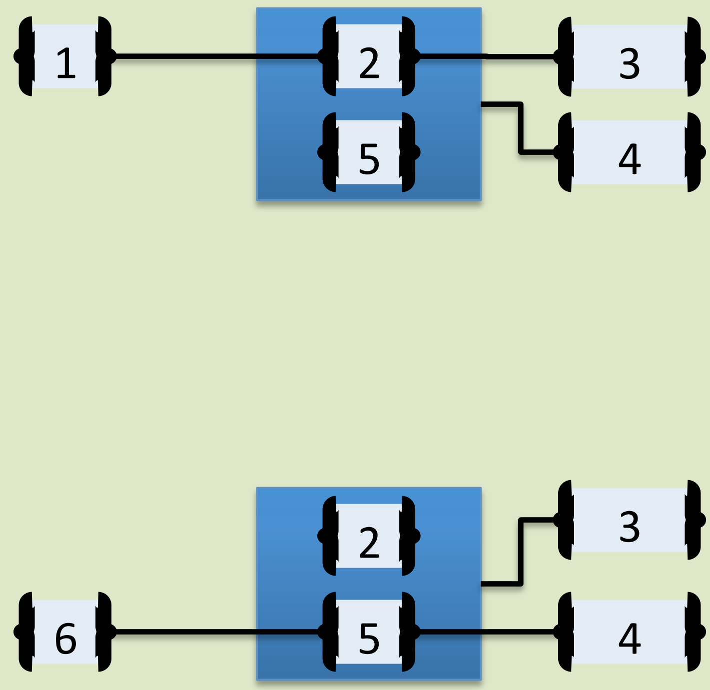




NHDP Example 9
Dual Interface on All Routers

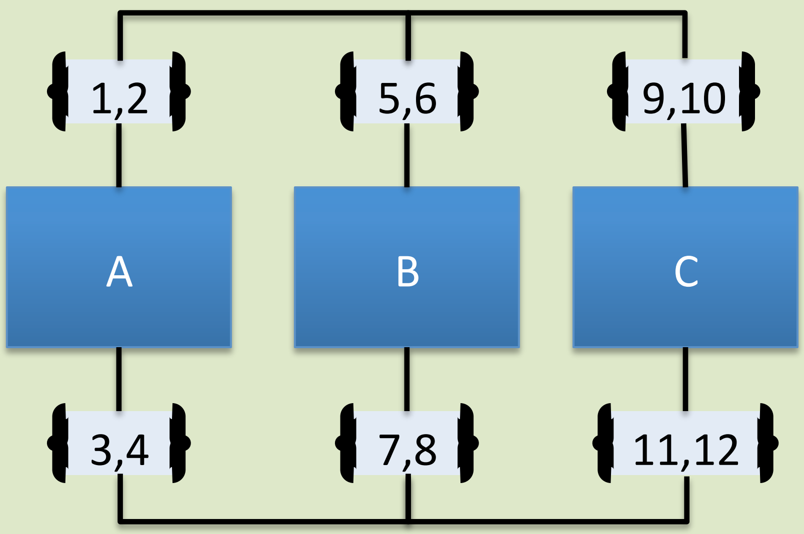


Physical Network Topology

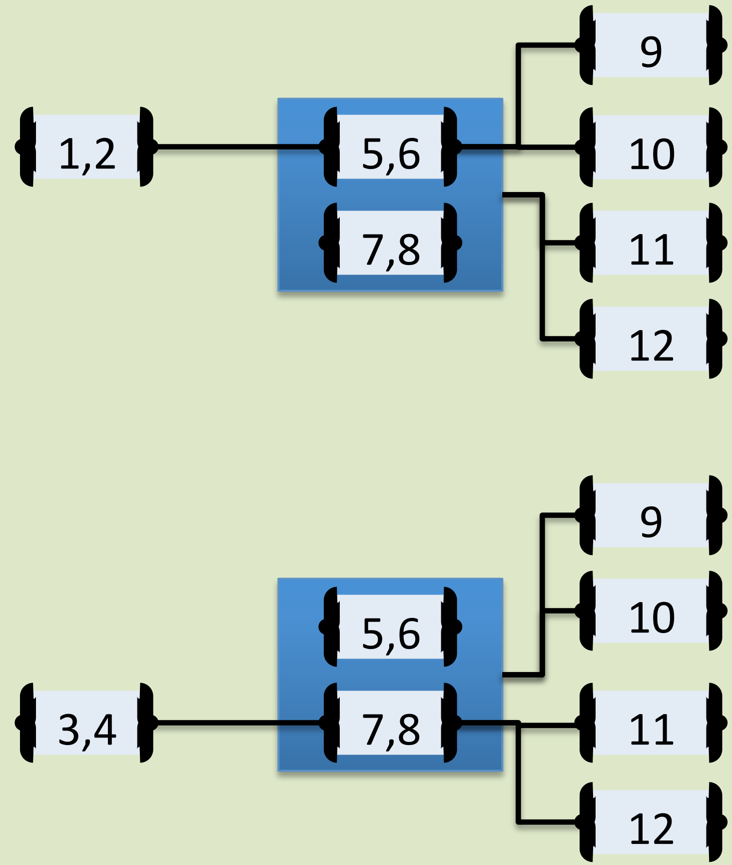


NHDP Representation

NHDP Example 1
Dual Addressed Dual Ifaces on All Routers



Physical Network Topology



NHDP Representation

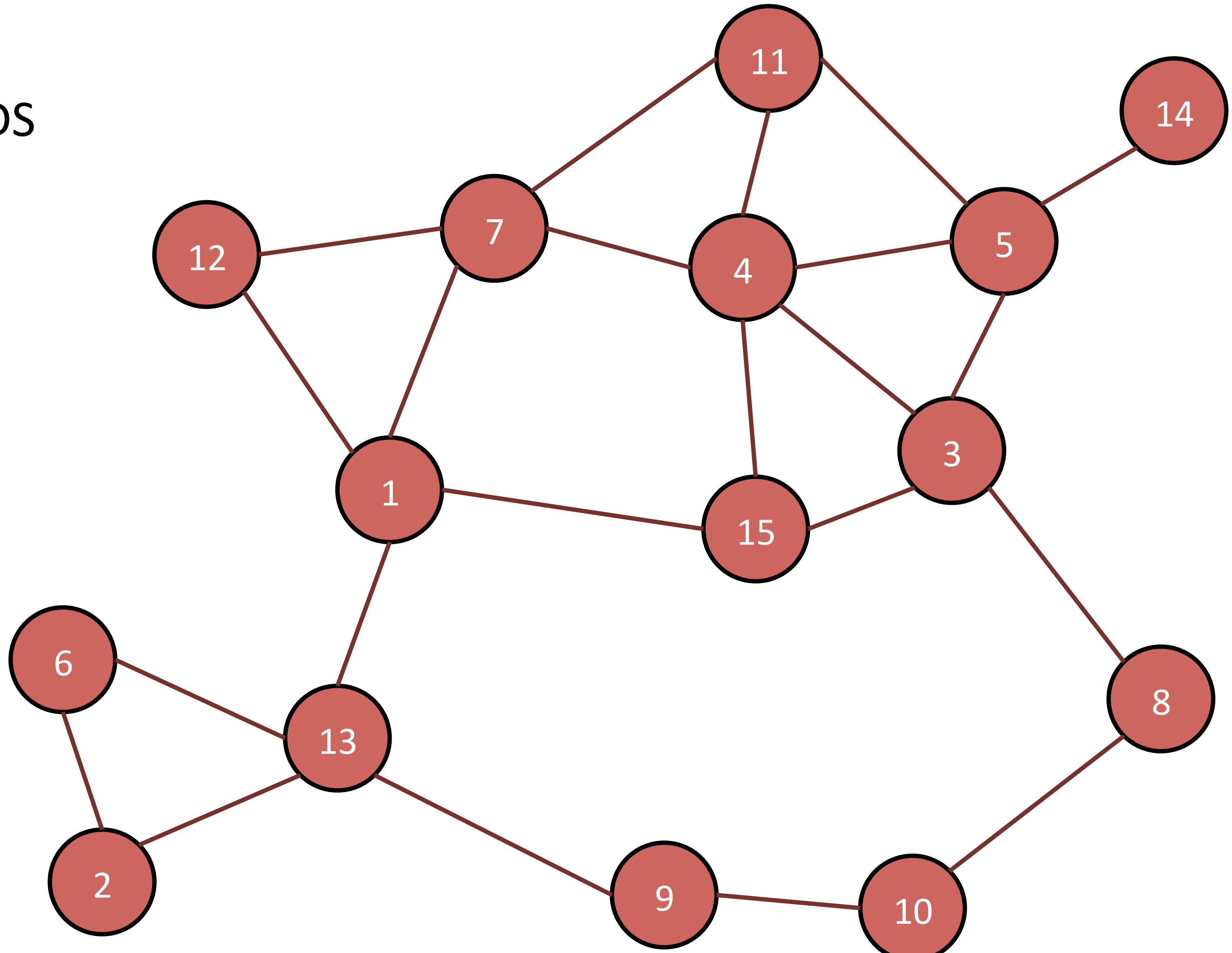
Simplified Multicast Forwarding (SMF) RFC 6621 CDS Election Overview

What is SMF?

- Simplified Multicast Forwarding
  - provides basic IP multicast forwarding suitable for MANET use
- Key Features
  - Duplicate packet detection
    - IP header dup ID
    - Hash based
  - Network wide dissemination
  - Reduced forwarding via connected dominating set (CDS) algorithms
  - Gateway to traditional Internet IP multicast

SMF CDS algorithms illustration:

- ECDS
- S-MPR
- MPR-CDS



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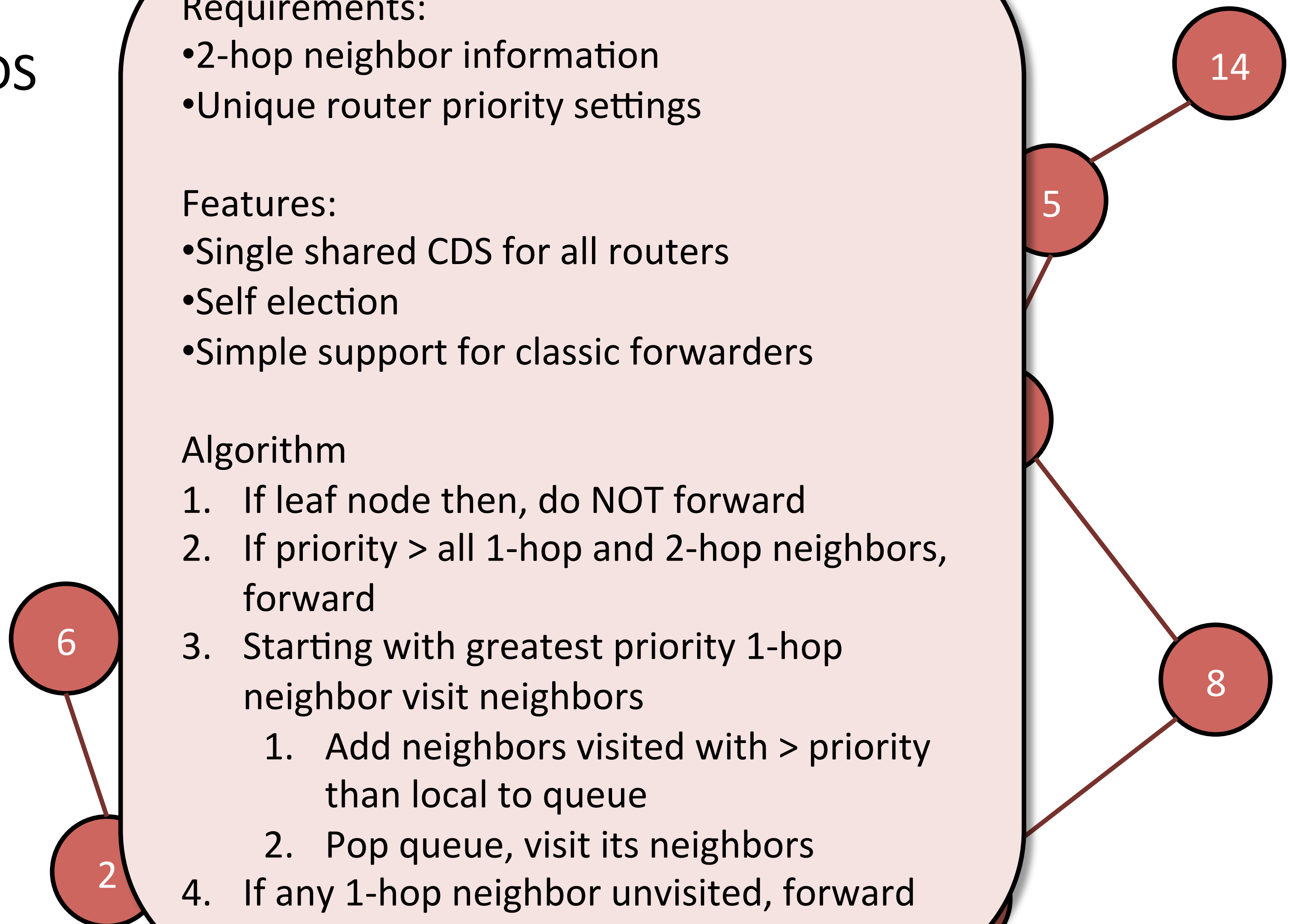


Requirements:
- 2-hop neighbor information
- Unique router priority settings

Features:
- Single shared CDS for all routers
- Self election
- Simple support for classic forwarders

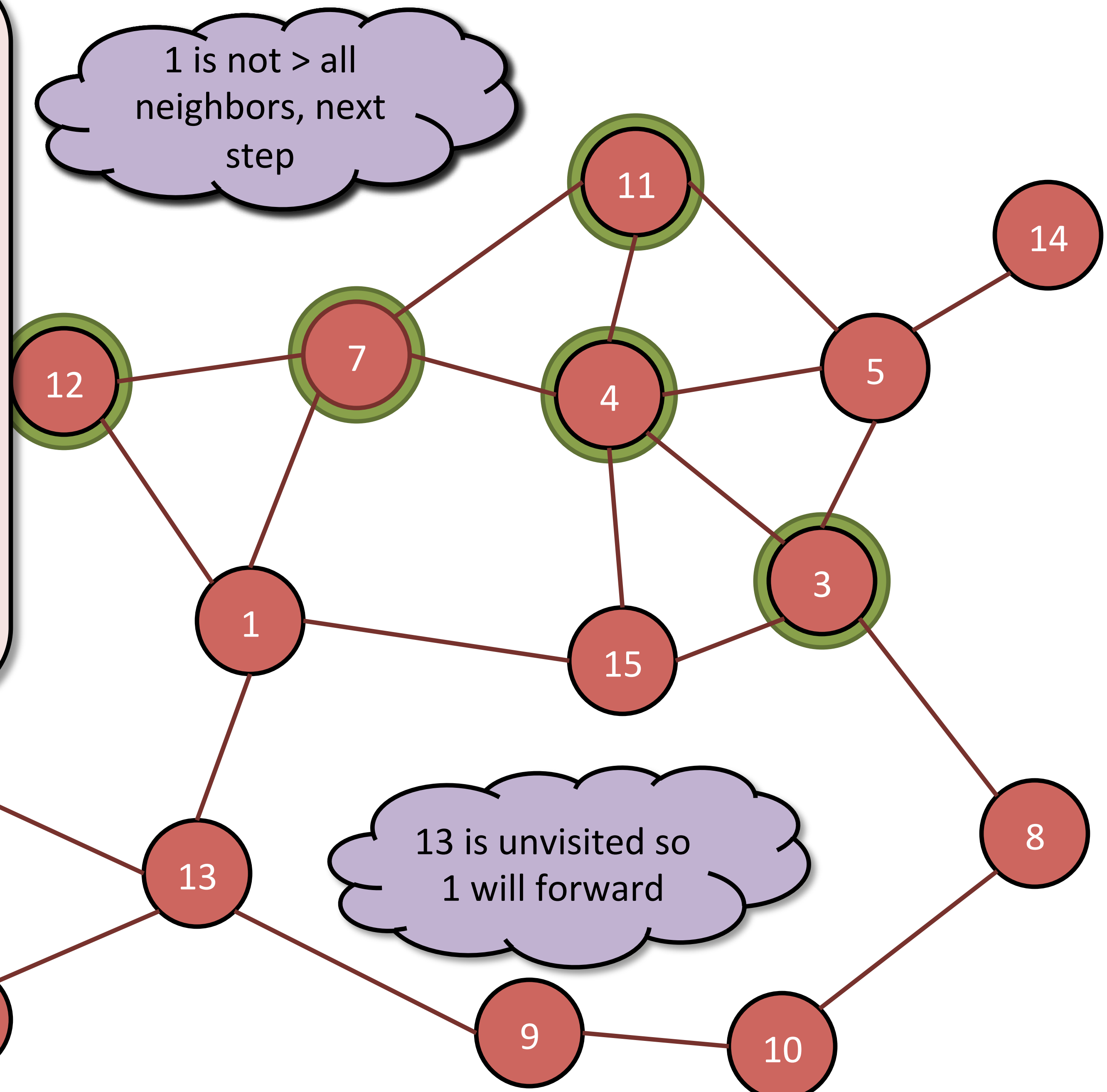
Algorithm
1. If leaf node then, do NOT forward
2. If priority > all 1-hop and 2-hop neighbors, forward
3. Starting with greatest priority 1-hop neighbor visit neighbors
   1. Add neighbors visited with > priority than local to queue
   2. Pop queue, visit its neighbors
4. If any 1-hop neighbor unvisited, forward

ECDS Requirements

- 2-hop neighbor information
- Unique router priority

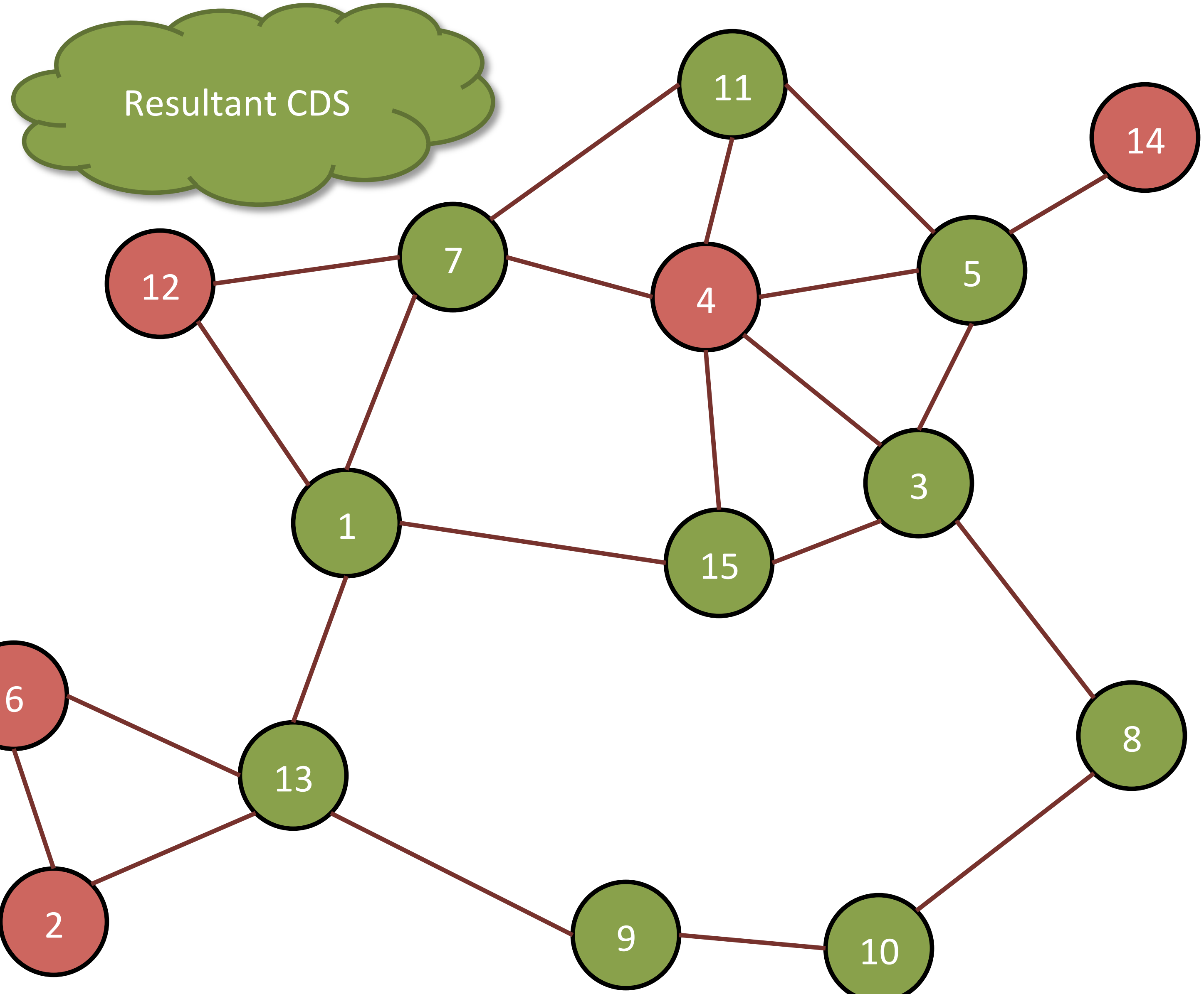
ECDS Algorithm

1. If leaf node then, do NOT forward
2. If priority > all 1-hop and 2-hop neighbors, forward
3. Starting with greatest priority 1-hop neighbor visit its neighbors
    1. Add neighbors visited with > priority than local to queue
    2. Pop queue, visit its neighbors
1. If any 1-hop neighbor unvisited, forward



SMF CDS algorithms illustration:

- ECDS
- S-MPR
- MPR-CDS



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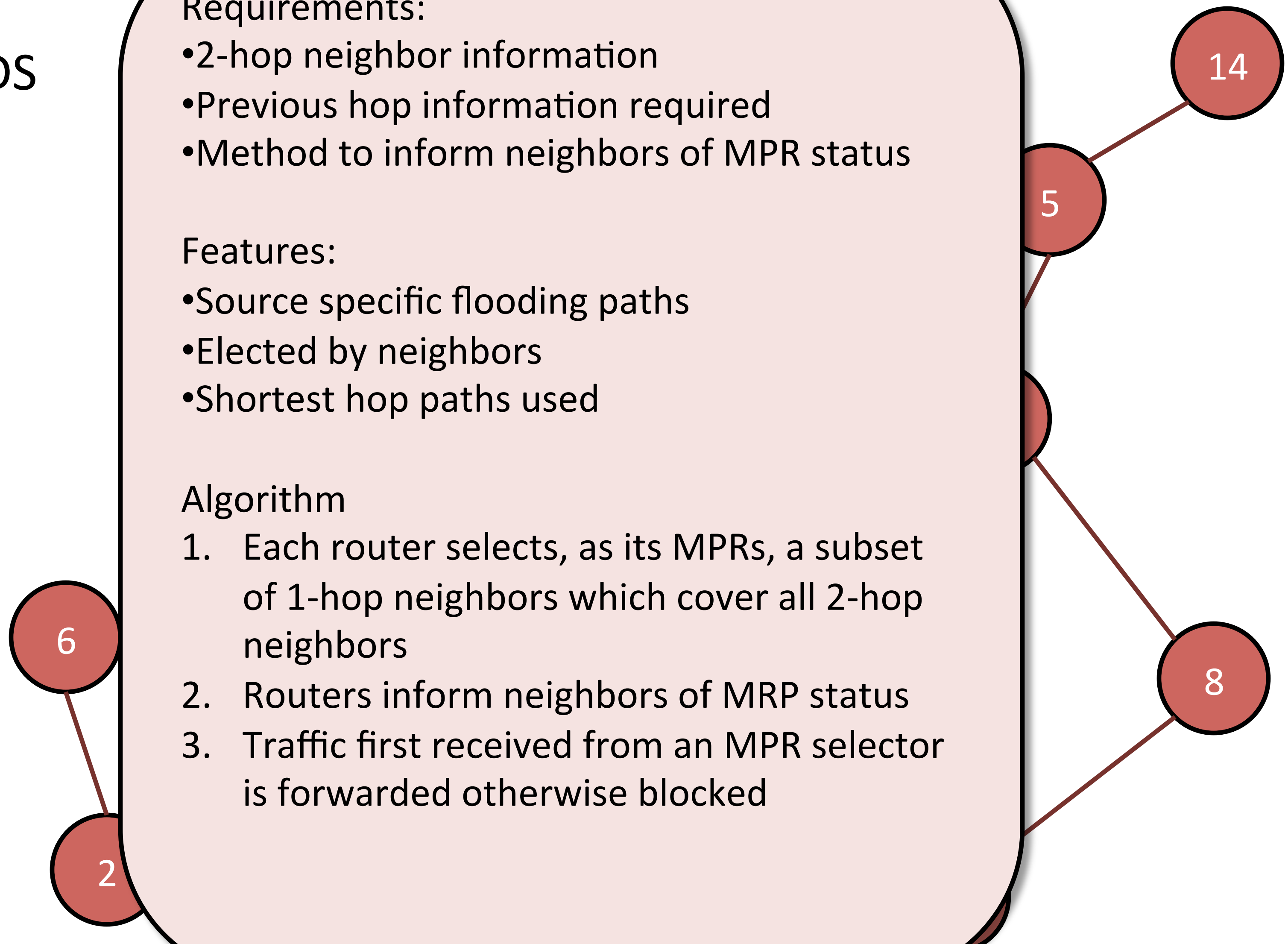


Requirements:

- 2-hop neighbor information
- Previous hop information required
- Method to inform neighbors of MPR status

Features:

- Source specific flooding paths
- Elected by neighbors
- Shortest hop paths used

Algorithm

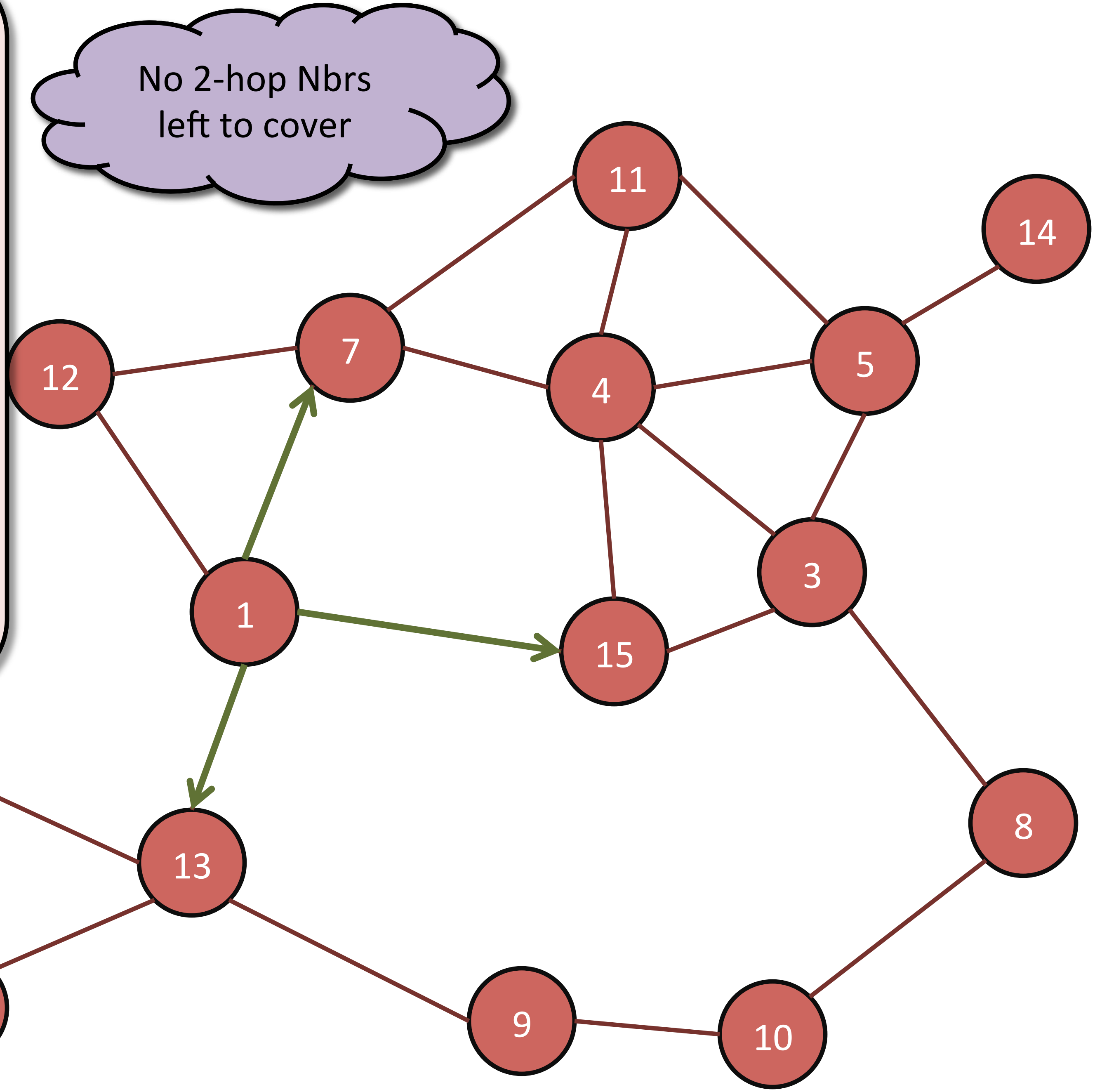
1. Each router selects, as its MPRs, a subset of 1-hop neighbors which cover all 2-hop neighbors
2. Routers inform neighbors of MRP status
3. Traffic first received from an MPR selector is forwarded otherwise blocked

S-MPR Requirements

- 2-hop neighbor information
- Previous hop information
- Method to inform Nbrs of MPRs

S-MPR Algorithm

1. Select MPRs
    1. Select 1-hop Nbr providing only path to 2-hop Nbr
    2. Select 1-hop Nbr which would cover most covered nodes
2. Inform neighbors of MPR status
3. Traffic first received from an MPR selector is forwarded
4. Traffic first received from a non-MPR select is blocked



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- ECDS
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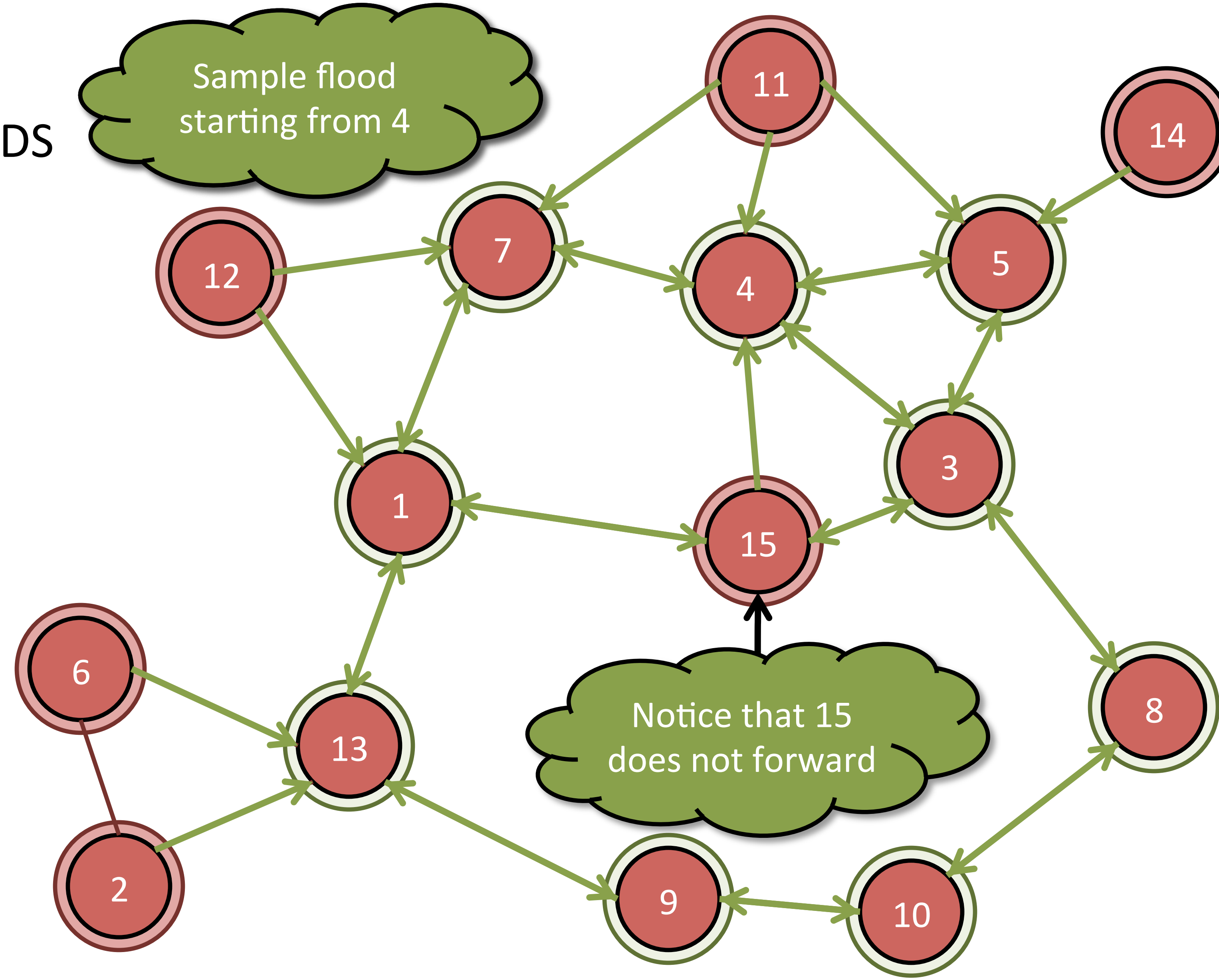

SMF CDS algorithms illustration:

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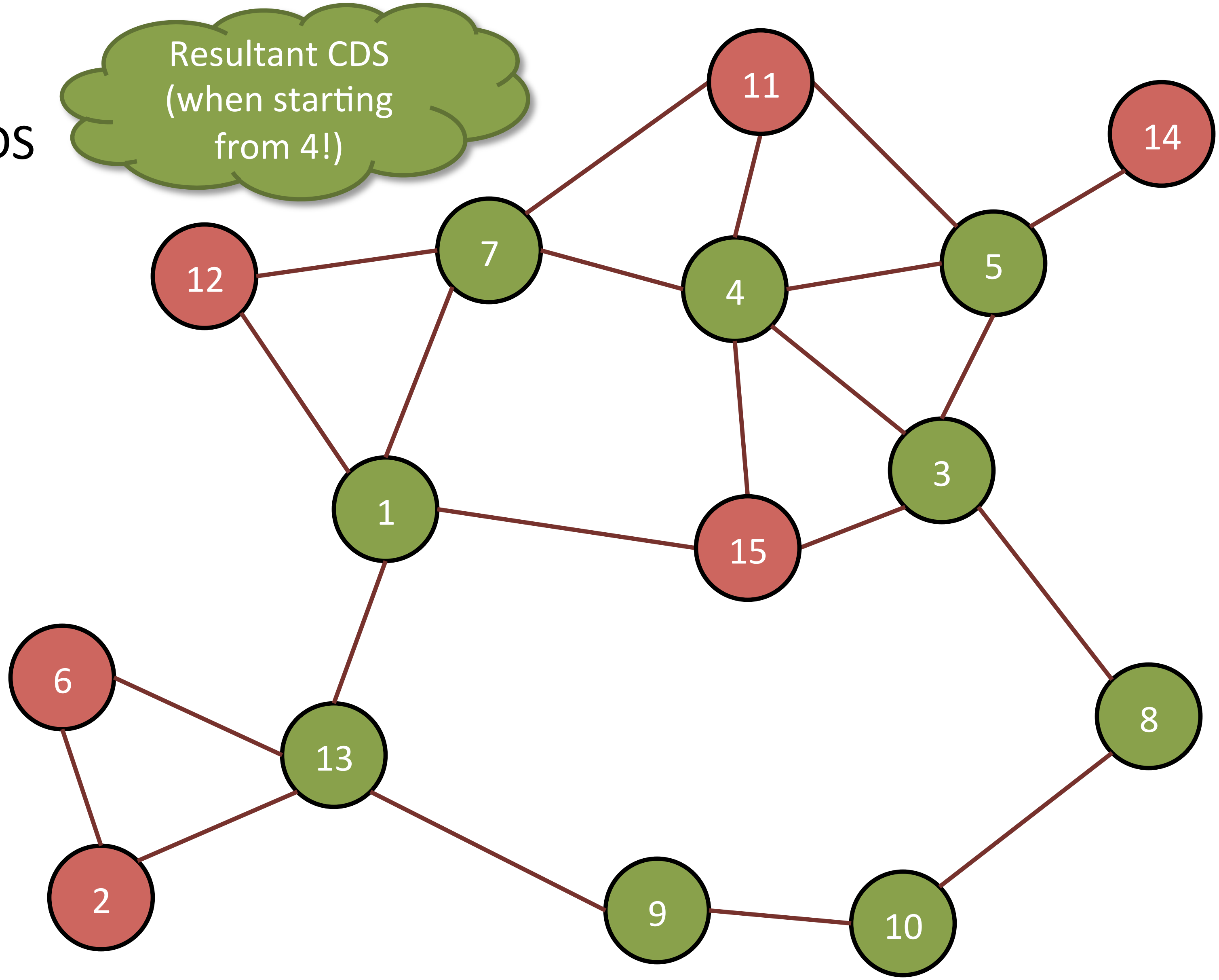

SMF CDS algorithms illustration:

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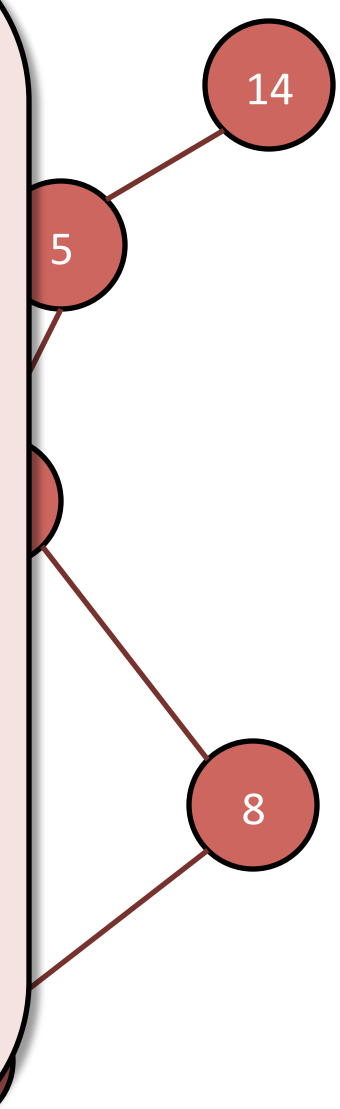
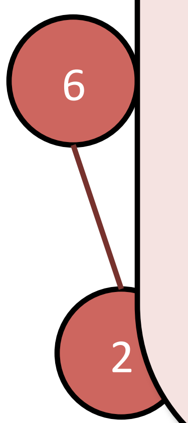
Requirements:
- 2-hop neighbor information
- Method to inform neighbors of MPR status
- Unique router priority settings

Features:
- Single shared CDS for all routers

Algorithm
1. MPR election is performed and shared in the same way as S-MPR
2. Routers which have been selected as an MPR by any other router forward if
    1. it has larger priority than all of its 1-hop neighbors
    2. the 1-hop neighbor with the largest priority has selected it as an MPR





MPR-CDS Requirements

- 2-hop neighbor information
- Method to inform Nbrs of MPRs
- Unique router priority settings

MPR-CDS Algorithm

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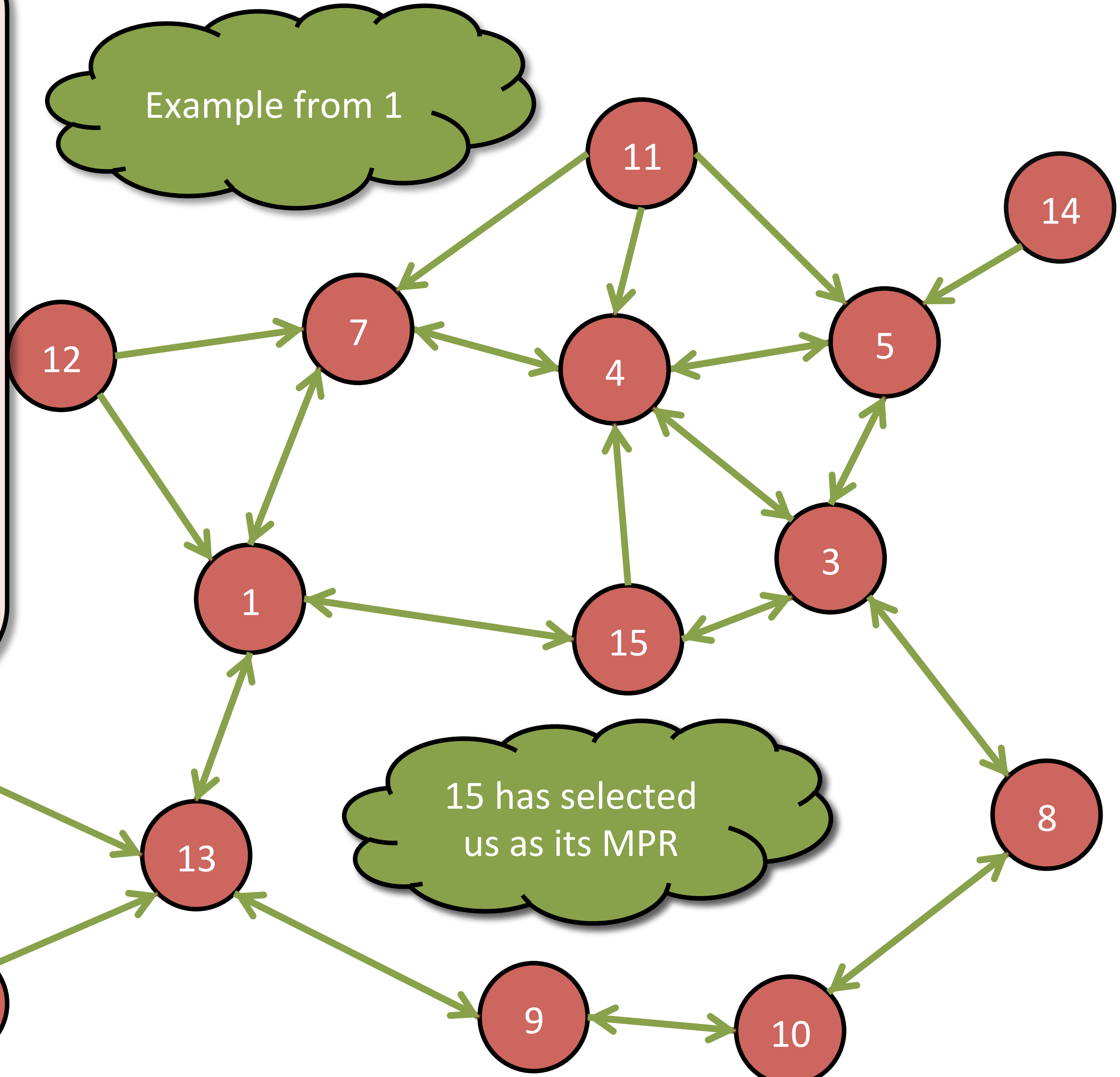

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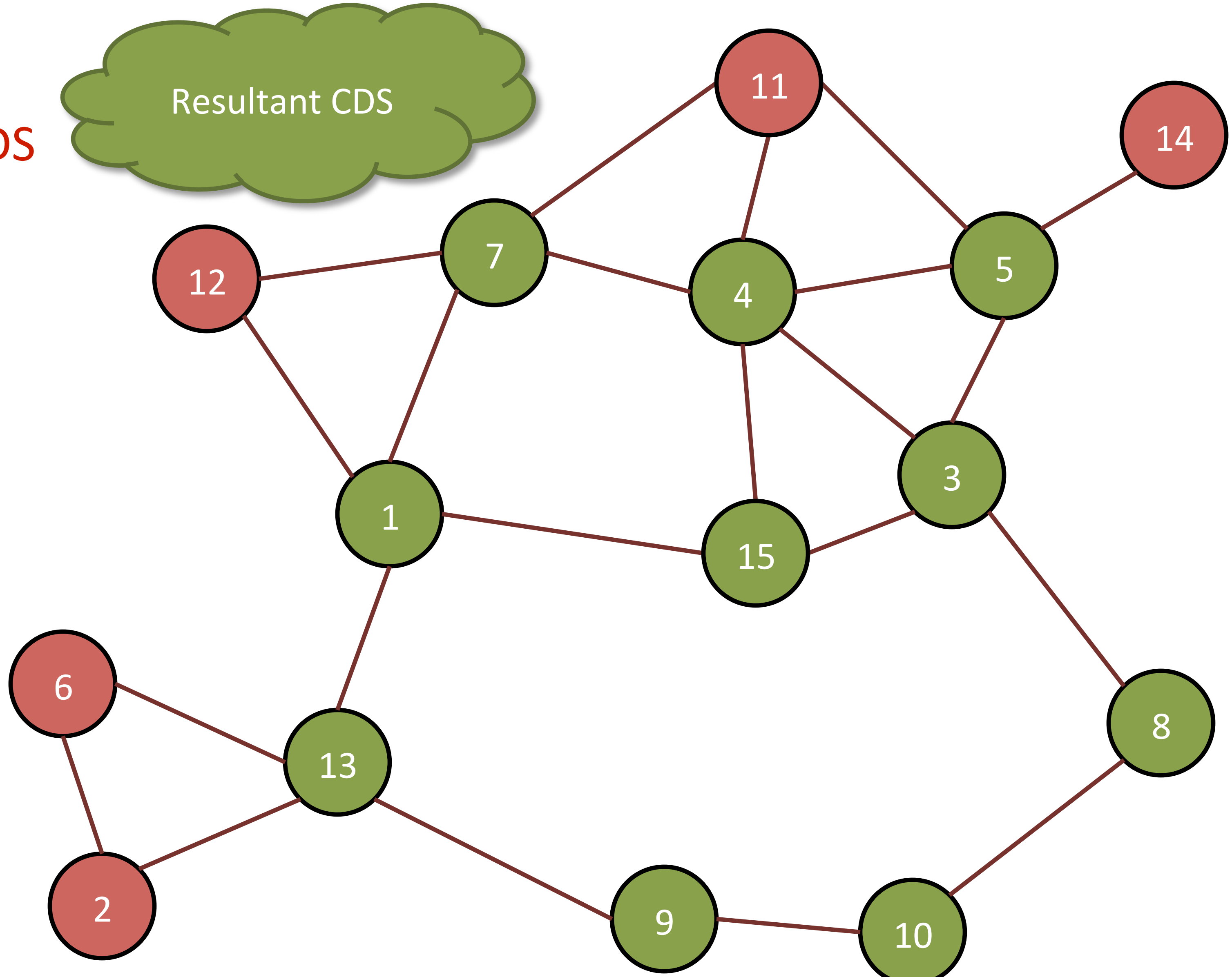


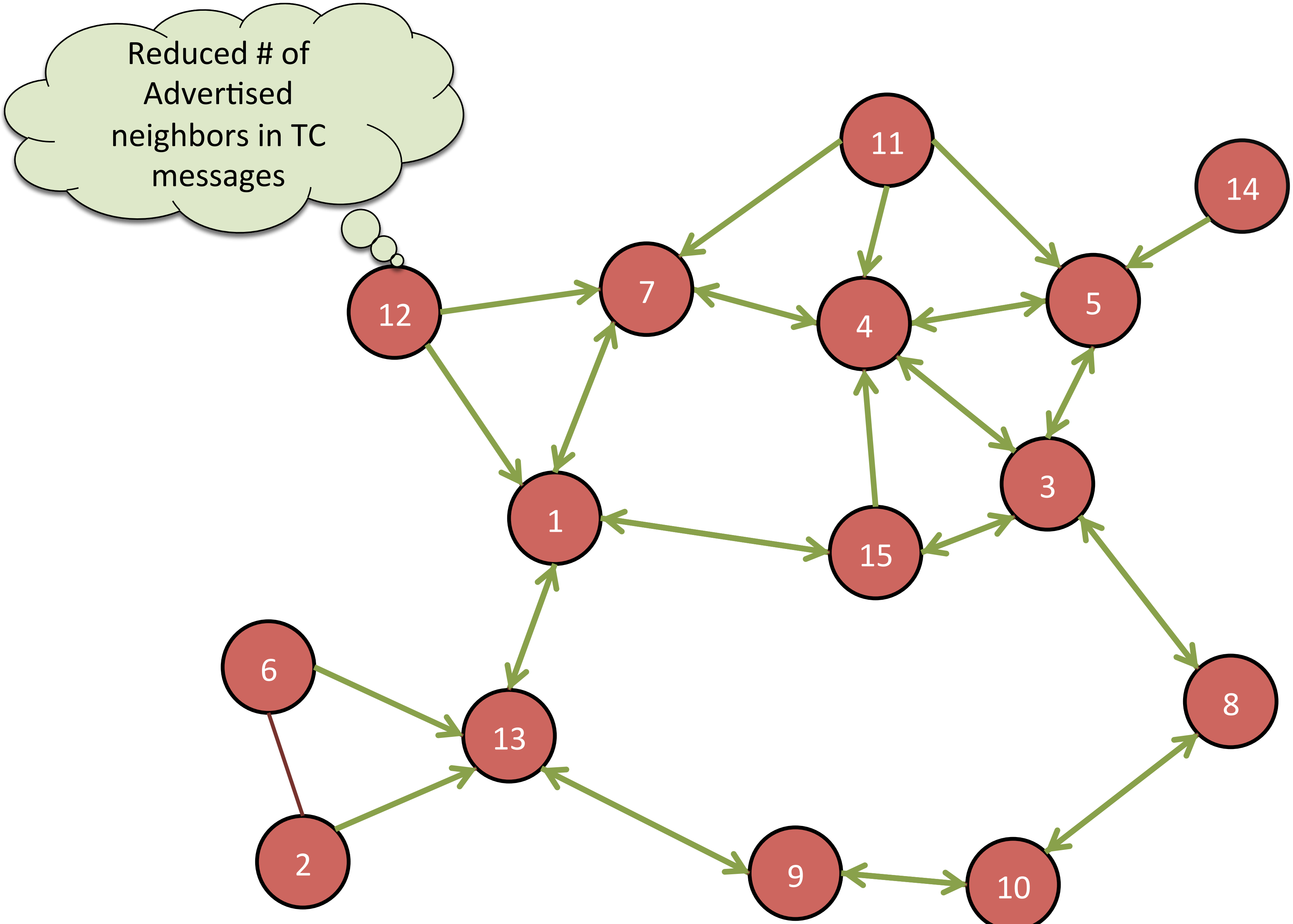
Optimized Link State Routing Protocol v2
RFC 7181 Overview

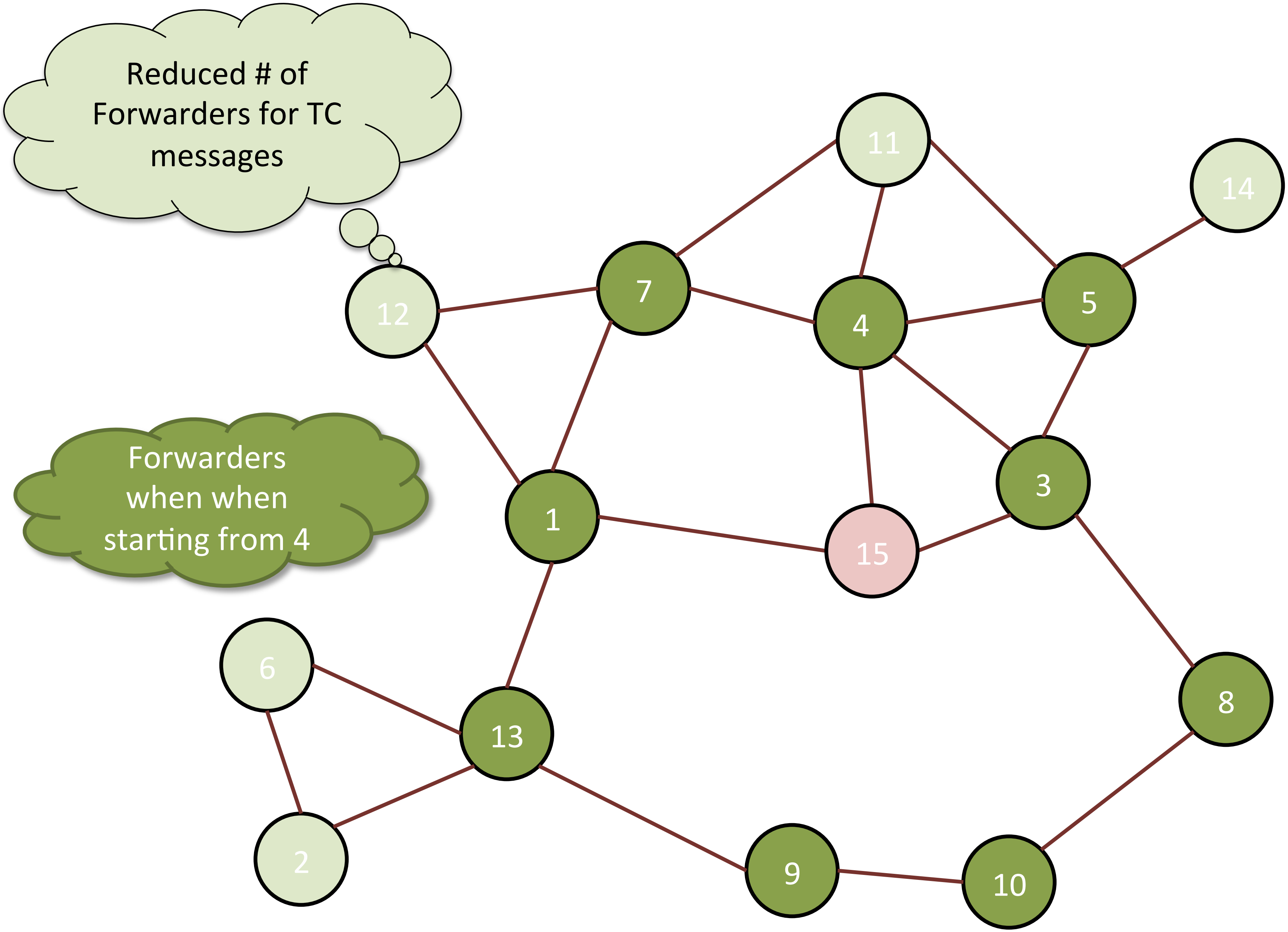
What is OLSRv2?

- Optimized Link State Routing Protocol v2
  - A proactive unicast routing protocol for use in MANET networks.
- Key Features
  - Uses NHDP
    - Uses two hop information
    - Augments NHDP hello messages with OLSRv2 specific TLVs
  - Metric Support
  - Use of multi-point relay for disseminating network topology using reduced forwarding set
  - Supports attached networks
  - Provides shortest path routes
  - Dynamic Timers

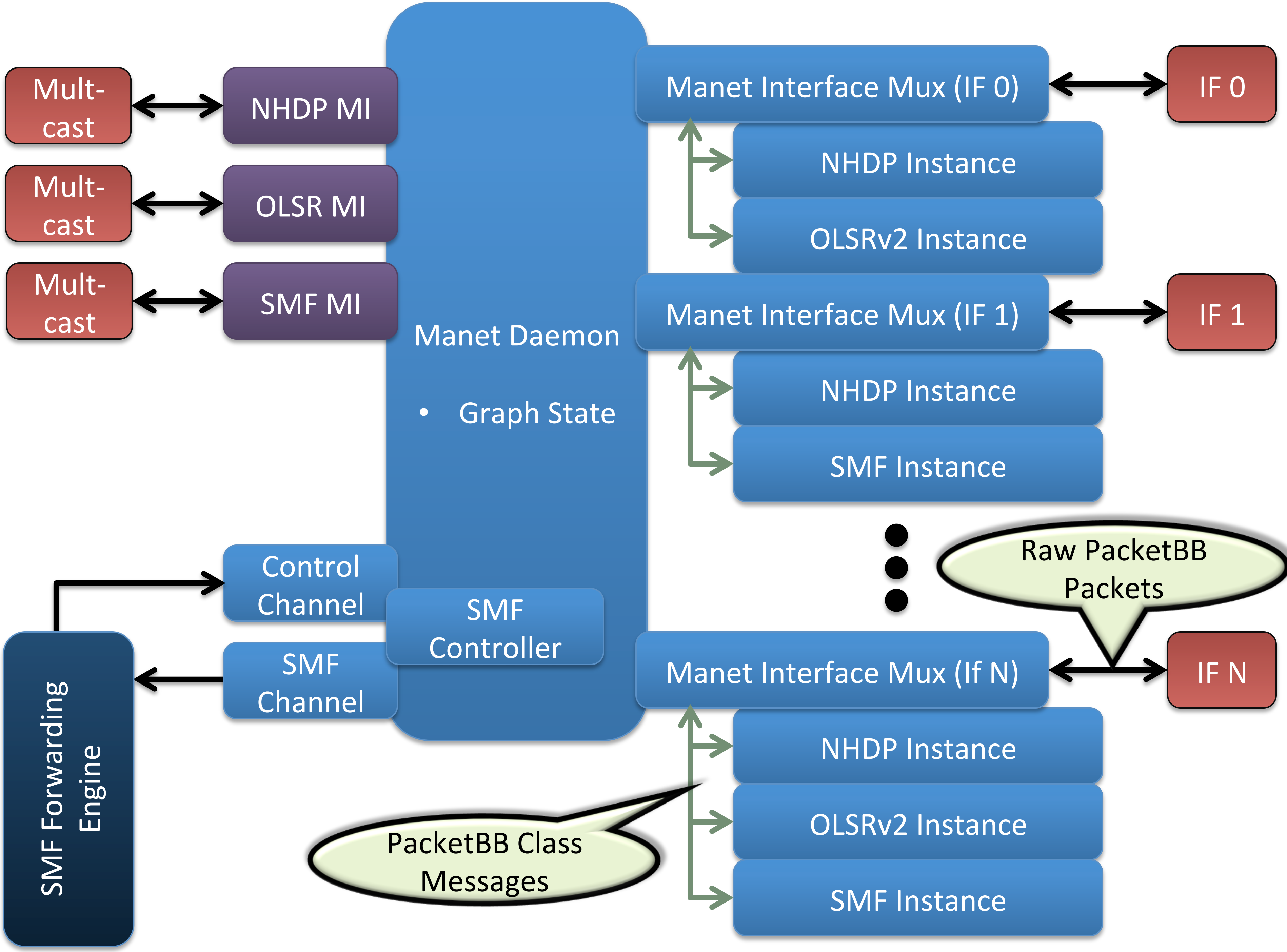
What's Optimized about OLSRv2?

- Reduced number of routers sourcing TC messages
  - Only routers selected as MPR source TC messages
- Reduced advertised address included in topology control (TC) messages
  - Only MPR selectors are advertised
- Reduction of forwarded TC messages using MPR election
  - Only MPR neighbors rebroadcast TC messages.
- Dynamic + distance based timers
  - allow dynamically slower update rates
  - allow limited flooding of TC messages (e.g. fisheye or hazy flooding)


Reduced # of Advertised neighbors in TC messages
11
14
7
4
5
12
3
1
15
6
13
8
2
9
10



Reduced # of Forwarders for TC messages
Forwarders when when starting from 4
11
14
7
4
5
12
1
15
3
6
13
8
2
9
10


Mult-
cast
NHDP MI
Mult-
cast
OLSR MI
Mult-
cast
SMF MI
Manet Daemon
• Graph State
Manet Interface Mux (IF 0)
IF 0
NHDP Instance
OLSRv2 Instance
Manet Interface Mux (IF 1)
IF 1
NHDP Instance
SMF Instance
Raw PacketBB Packets
Control Channel
SMF Controller
SMF Channel
Manet Interface Mux (If N)
IF N
NHDP Instance
OLSRv2 Instance
SMF Instance
SMF Forwarding Engine
PacketBB Class Messages

Dynamic Link Exchange Protocol Overview

What is DLEP?

- Dynamic Link Exchange Protocol
- Key Features
  - Allows radios to indicate the characteristics of variable-quality RF links as they change
  - Routers can ask radio for specific data rate or delay
- DLEP specifies “what” data items get exchanged – NOT “how” those items are used

What is DLEP (continued)

- MANETs need to handle rapid mobility profiles
  - Both in terms of topology changes, and devices entering and leaving the network due to mobility
- In these environments, relying solely on ‘HELLO’ and ‘DEAD’ timers running at Layer 3 can be problematic
- And all the while, the link quality (speed, delay) can and does change
- Routers and radios **must** be able to signal each other in order for route tables to converge quickly
  - Convergence events are necessary to minimize black-holes and routing loops
  - Link metrics are needed to advertize the robustness of the path

What is DLEP (last slide - I promise)

- DLEP is specified as a 1-hop ONLY protocol
  - Multicast discovery ‘signals’ are sent/received with TTL=1
- TCP session employs the Generalized TTL Security Mechanism (GTSM – RFC 5082)
- ALL specified messages are designed to be exchanged between a radio and its **LOCALLY ATTACHED** routers
  - NO Over-The-Air (OTA) messaging is specified
  - However, some proprietary OTA signaling between modems and/or modem-to-hub is implicit

DLEP using multiple radios

Routers can use radio feedback to monitor link status and find the best wireless paths through complex networks

- **Optimizes IP routing over radio networks**
- **Immediately recognizes and adapts to network changes**
- **Easily routes between line-of-sight and non-line-of-sight links**