Developing the Multi-Node Label Routing Protocol

Erik Golen, Ph.D.

Information Sciences & Technologies Department

Agenda

- Modularity in networking and routing
- The Multi-Node Label Routing (MNLR) Protocol
- Label Assignment and Packet Forwarding
- Protocol Development Guidelines
- Protocol Performance
- Testbed Demo

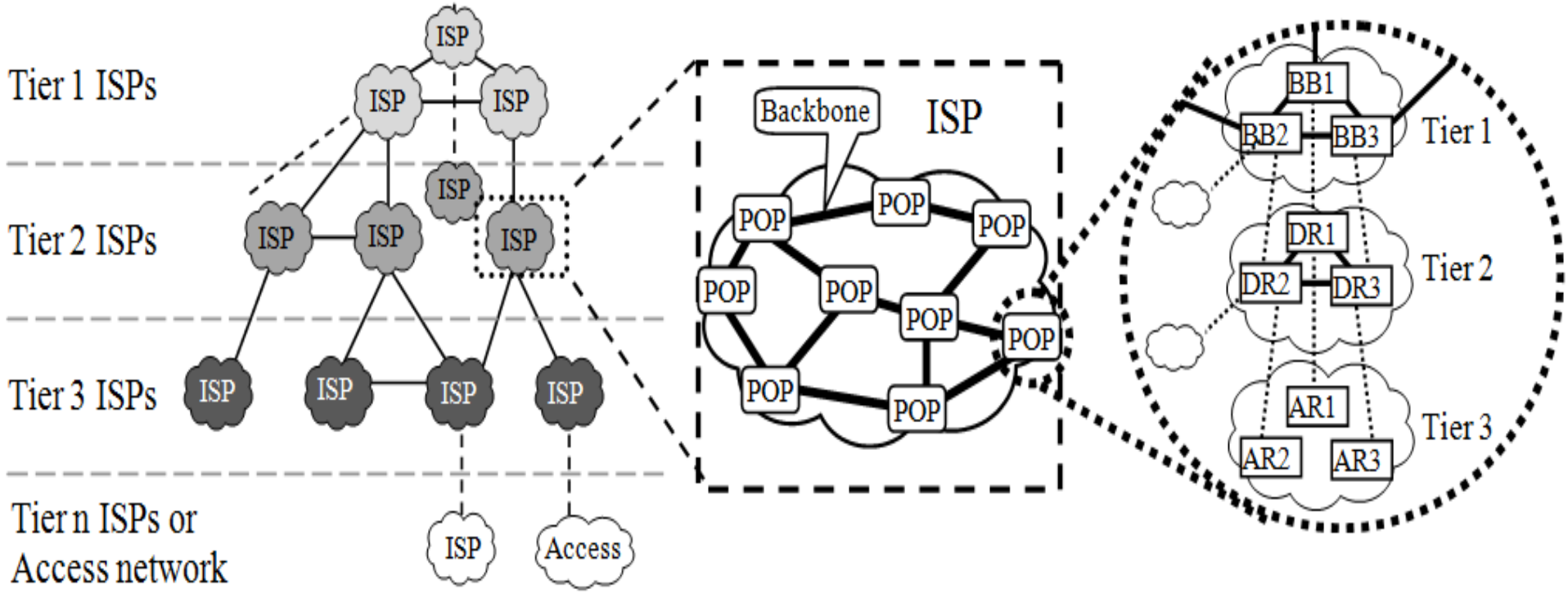
Modularity in Networks

- Routing Challenges
  - Huge routing table sizes – scalable?
  - Complex routing operations
  - High processing needs in routing equipment
  - Looping packets, routing paths?

Modularity in Routing

- Proposed Abstraction
  - Router Roles (functions & operations)
    - Backbone Routers
    - Distribution Routers
    - Access Routers
  - Modules will be the sets of routers
  - Routing needs a structure to provide a forwarding path
  - Associate the modules (sets of routers) to a structure

Modularity in Routing

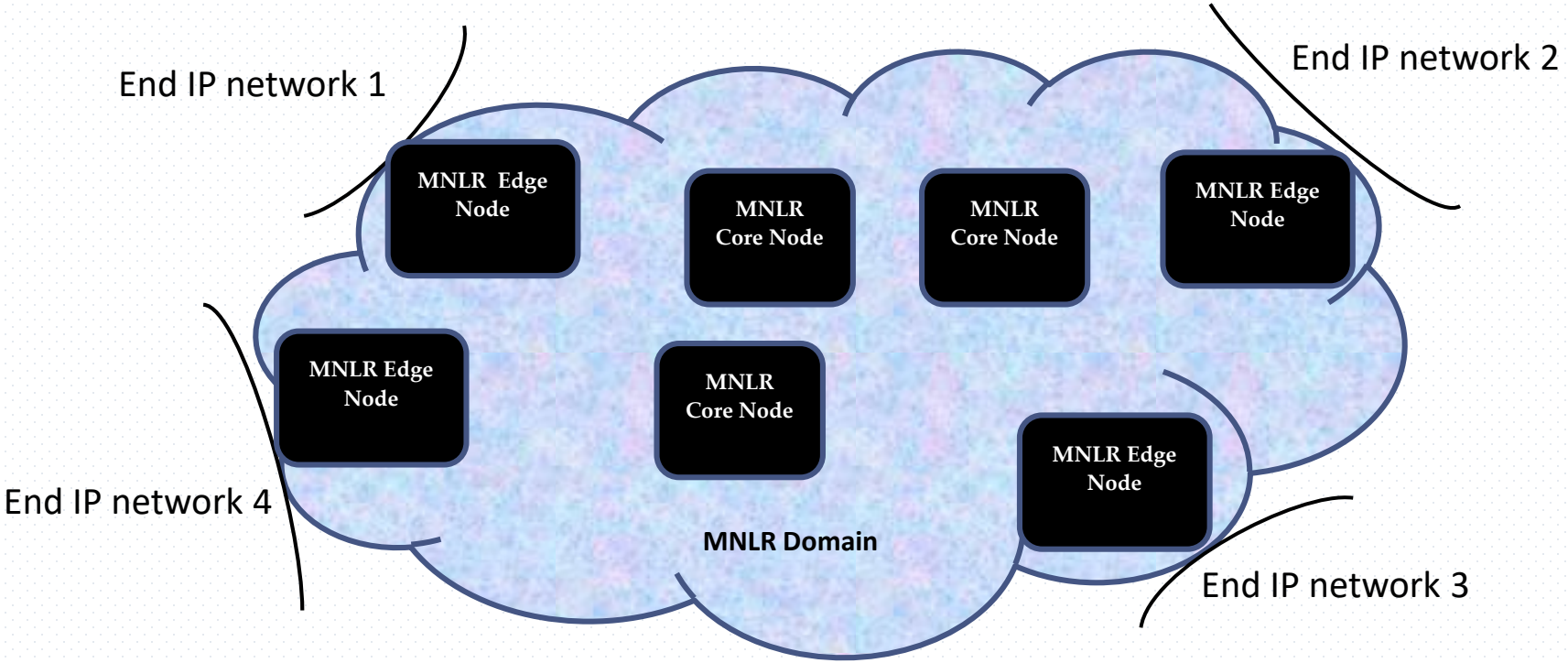


Highlights

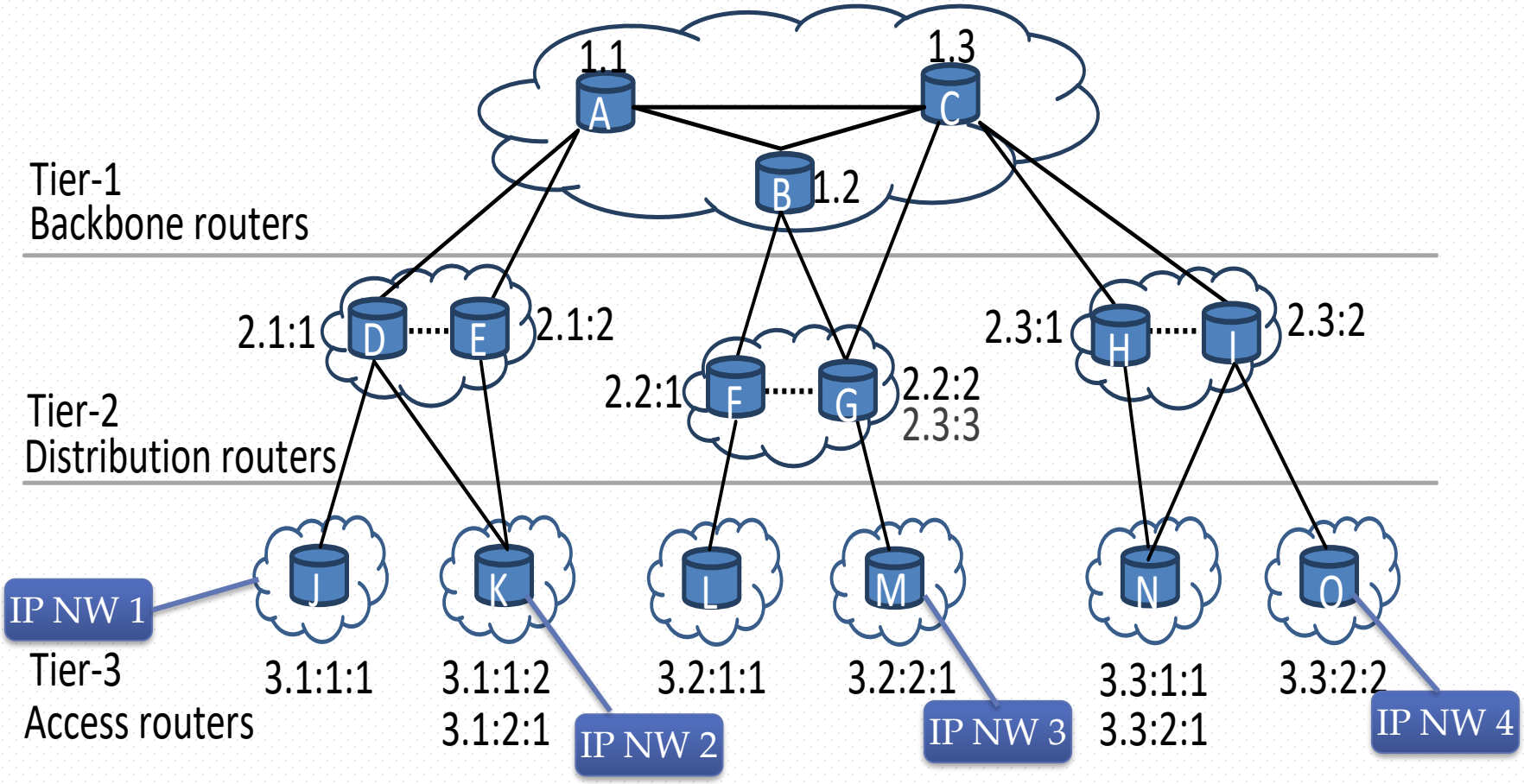
- No Need for two protocols – Internet Protocol and Routing Protocol
- No need for different routing protocols – inter-AS and intra-AS
- Reduced memory needs – only need to keep track of direct neighbors
- Reduced processing complexity
- Reduced energy consumption

An MPLS–like approach

- Protocol at Layer 2.5 (***Use or fall back to IP***)
- Multi Node Label (based) Routing – MNLR protocol



Assigning Labels to MNLR Nodes

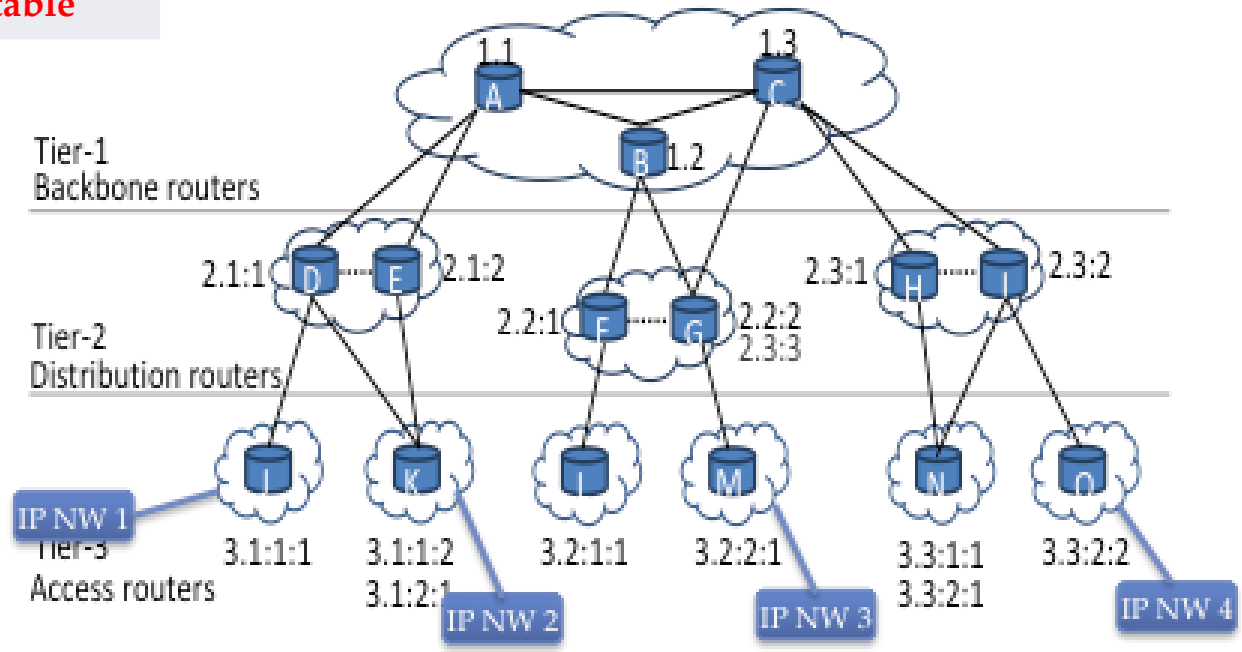


Auto Assignment / Configuration Needs

Tables

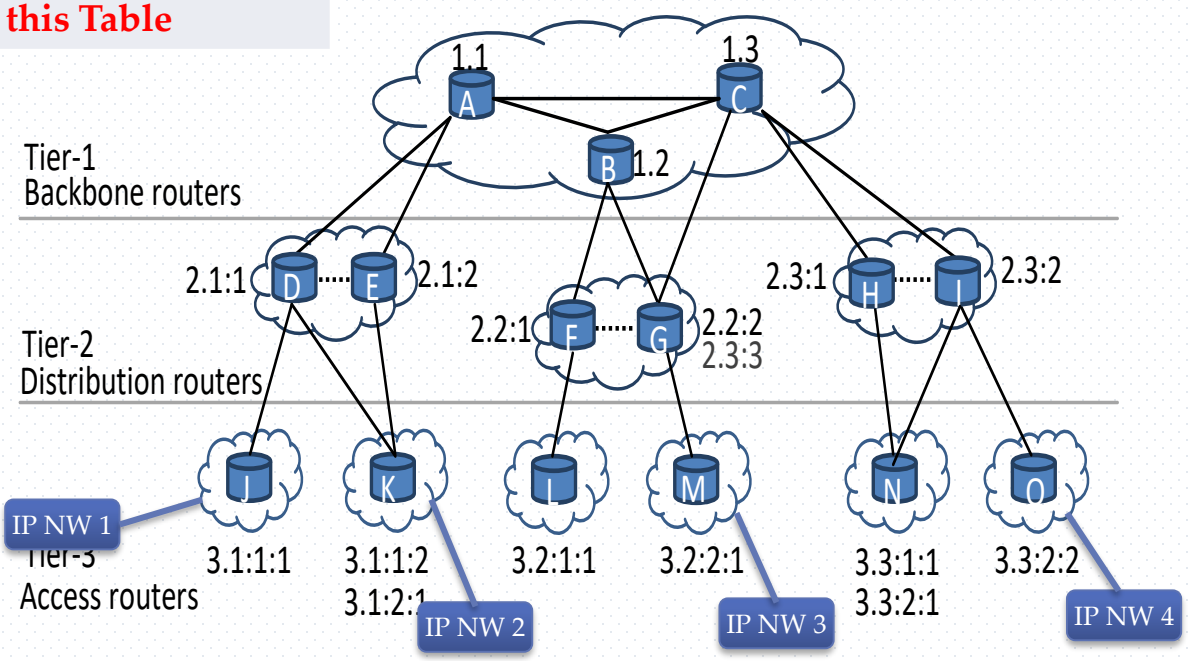
Label	Port
1.2	1
1.3	2
3.2:2:1	3
2.2:1	4
Neighbor Table (2.2:2)	
All Nodes Populate this table	

IP Network Address	Port
10.10.3.0/24	2
10.10.2.0/24	3
10.10.1.0/24	4
IP Address to Port Mapping	
Only Edge Nodes have this table	

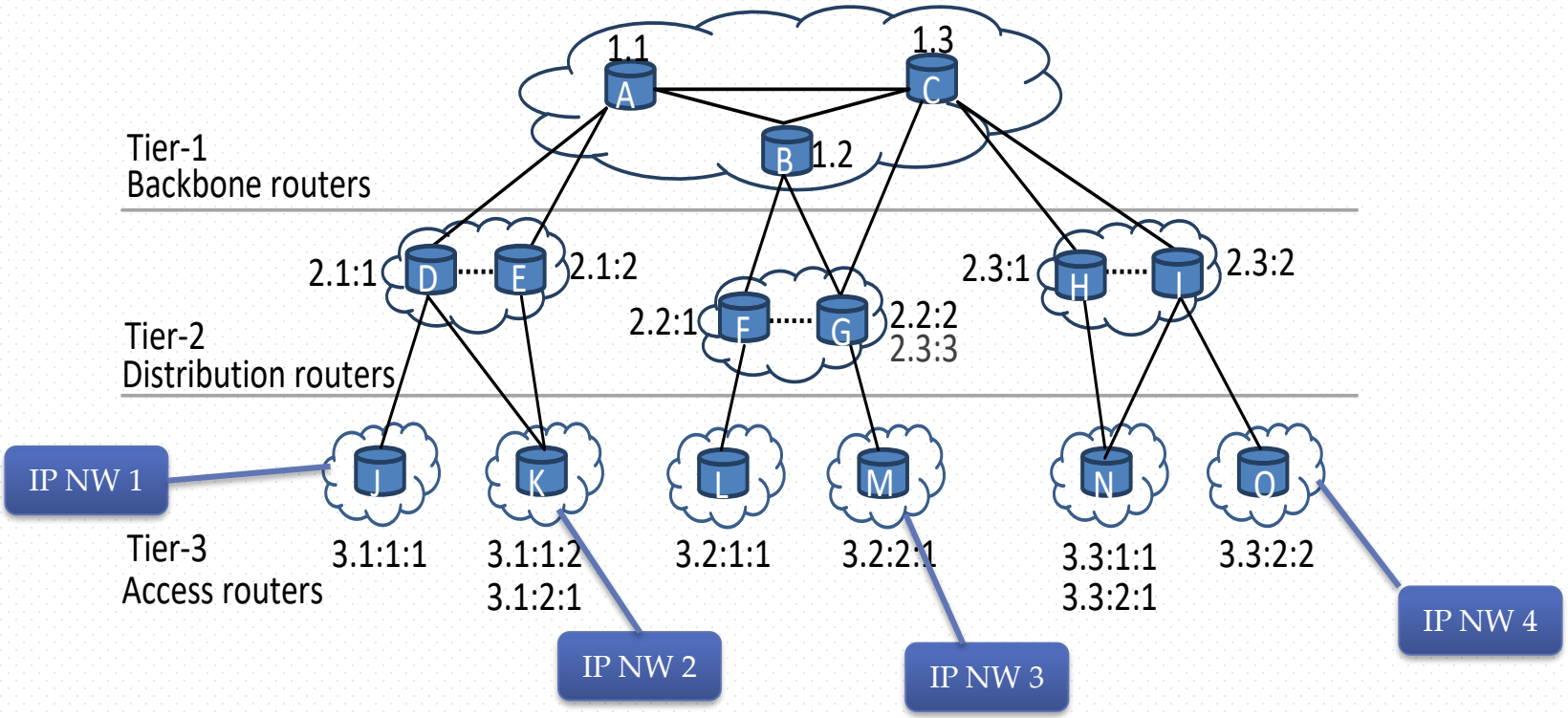


Tables

Label	IP Network Address
3.3:1:1	10.10.3.0/24
	10.10.2.0/24
	10.0.1.0/24
3.1:1:1	10.11.3.0/24
	10.11.2.0/24
	10.1.1.0/24
IP Address to Label Mapping	
Only Edge Nodes Populate this Table	



Packet forwarding in MNLR Domain



Packet from NW 1 to NW 2

Router J looks at it Label to IP address Map, determines the destination Node MNLR Label

Encapsulates the IP packet in MNLR header, with Source Label, Destination Label

Forwarding algorithm makes all routing decisions

Node K receives the MNLR packet

Node K de-encapsulates IP Packet, checks its IP NW – Port Address table

Forwards IP packet on that port

Developing a Network Protocol

- Define the behavior of the protocol
  - How do we route/forward?
- Define any tables that the protocol needs
  - What information do we need to keep track of?
- Define message formats
  - How do we disseminate information so that the various tables can be filled out by the network devices?

MNLR Message Formats

Hello message (MSG_TYPE 0x01)

1 byte	1 byte	1 byte	m bytes	…	1 byte	m bytes
MSG_TYPE	Number of Tier Addresses	Tier Address Length 1	Tier Address 1	…	Tier Address Length n	Tier Address n

Encapsulated IP Message (MSG_TYPE 0x02)

1 byte	1 byte	n bytes	1 byte	m bytes	p bytes
MSG_TYPE	Destination Tier Address Length	Destination Tier Address	Source Tier Address Length	Source Tier Address	Payload (IP Header + IP Payload)

IP to Tier Address Mapping Message (MSG_TYPE 0x05)

1 byte	1 byte	1 byte	1 byte	m bytes	1 byte	p bytes	1 byte
MSG_ TYPE	Number of Entries	Operation	Tier Address Length i	Tier Address i	IP Address Length i	IP Address i	CIDR i

Protocol Performance

- Want to show that the performance of your protocol is better than competing protocols
  - Throughput
  - End to end delay
  - Energy consumption
  - Routing table size
  - Convergence time (initial and after topology change)
- Compare performance of MNLR with BGP (inter-AS routing) and OSPF (intra-AS routing)

Protocol Performance

- How can we compare the performance of two or more protocols?
  - Analytically determine performance by mathematically modeling the protocol
  - Perform simulations in a simulator like OPNET
  - **Actually run the protocols in a testbed environment like Emulab or GENI**
  - Physically build a network and run the protocols on it

Next Steps

- Demonstrate MNLR at the National Science Foundation in December and doing a live comparison with BGP
- Continue to automate the process of running MNLR and collecting metrics
- Implement auto label assignment for nodes at Tiers 2 and higher
- Modify MNLR so that it will run using a controller in a Software Defined Networking configuration