An Expedited Internet Bypass Protocol – Improving Internet Performance

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Agenda

- Growing complexity in Internet operations
  - Escalating Proprietary Solutions & Infrastructure Costs
- Unaddressed needs
  - For critical communications and emerging communication needs
- The Expedited Internet Bypass Protocol (EIBP) - A Cost Effective – Low Complexity Solution
  - Works in parallel to IP
  - Can be tailored to specific application needs
- Studies of EIBP vs IP&BGP, IP&OSPF
- Discussions / Questions

Growing Internet Challenges

- Number of Internet Users and Networks continue to grow
  - How are we coping?
- Applications using Internet continue to grow
  - IoT, Cloud assisted automation, industrial networks etc.
- Unaddressed Needs
  - Emergency, federal and defense networks (security, privacy, reliability)
- Internet Communications
  - Data plane IP (unreliable, no guarantees of delivery)
  - Control plane - BGP and OSPF uses IP to disseminate

Current Demand Scenario

APPLICATIONS

- Federal, Defense Emergency networks..
- Secure, reliable and high speed services

SERVICES

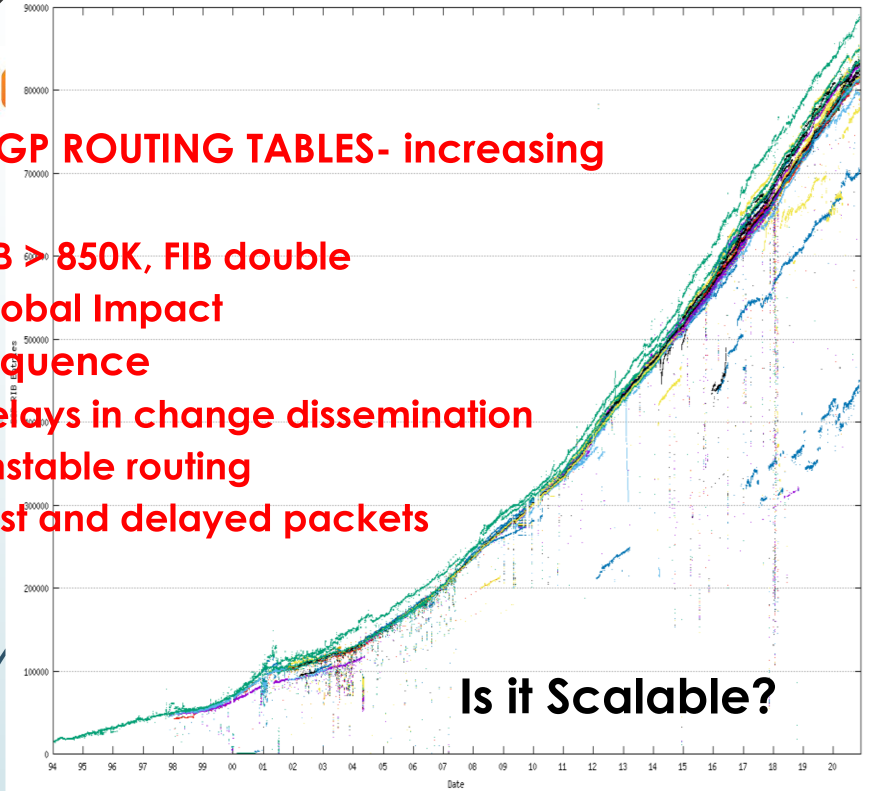
- Heavy demand for content delivery
  - CDN providers and networks
- High infrastructure investment
  - Overlay POPs to host content
  - Private CDNs, Private WANs (GAFAM - Google, Amazon, Facebook, Apple, Microsoft)
  - Interwoven to work with and use IP
  - Use modified versions of BGP, MPLS ++

OTHERS ?

APPLICATIONS

- IoT proliferation
- Industry Networks
- Automation

Current Internet Scenario



- IPV4 BGP ROUTING TABLES- increasing
  - RIB > 850K, FIB double
  - Global Impact
- Consequence
  - Delays in change dissemination
  - Unstable routing
  - Lost and delayed packets

Is it Scalable?

My Picture

Internet Traffic Prediction

Predicted global Internet traffic by year[26]

Year	Fixed Internet traffic (PB/month)	Mobile Internet traffic (PB/month)
2017	83,371	11,183
2018	102,960	16,646
2019	127,008	24,220
2020	155,121	34,382
2021	187,386	48,270

What happens to critical traffic? – Emergency, automation?

What is holding Internet up?

- Chip technologies?
- Fiber?
- Props and overlays from Big Investors?

How to Address the Challenges

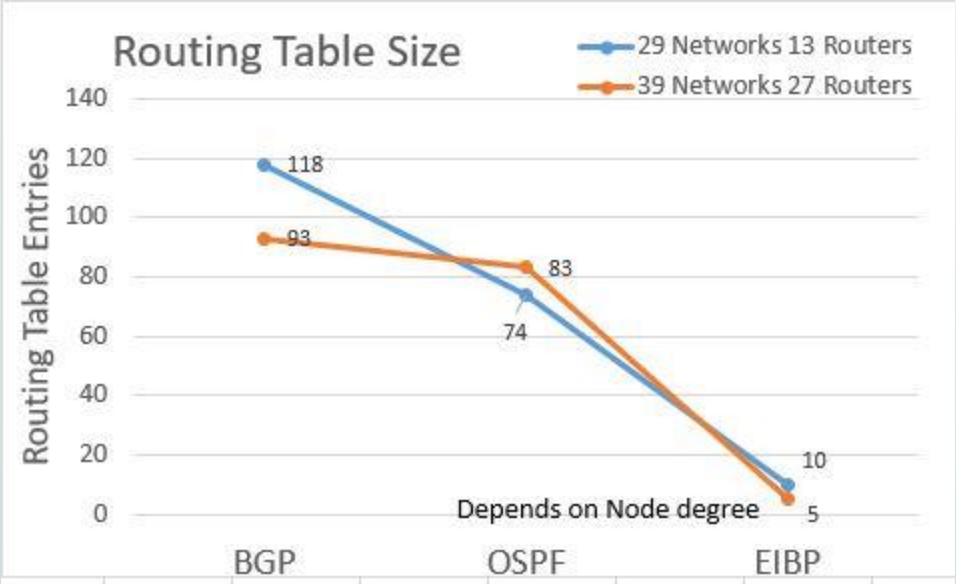
- Improve the Internet? – We are trying…………….
- Replace the Internet? ……….we tried…. Future Internet Architectures
- Provide props – we are doing (overlays, underlays)
  - Costly and complex, still depend on IP and its unstable routing

Do all services need special treatment?

- Bypass the Internet for specific services
  - The Expedited Internet Bypass Protocol (EIBP)
  - Currently EIBP forwards using end IP network (host) addresses
  - Can define new addresses, introduce prioritized services
- Two protocols IP and EIBP can work side by side – EIBP may offload some traffic from IP

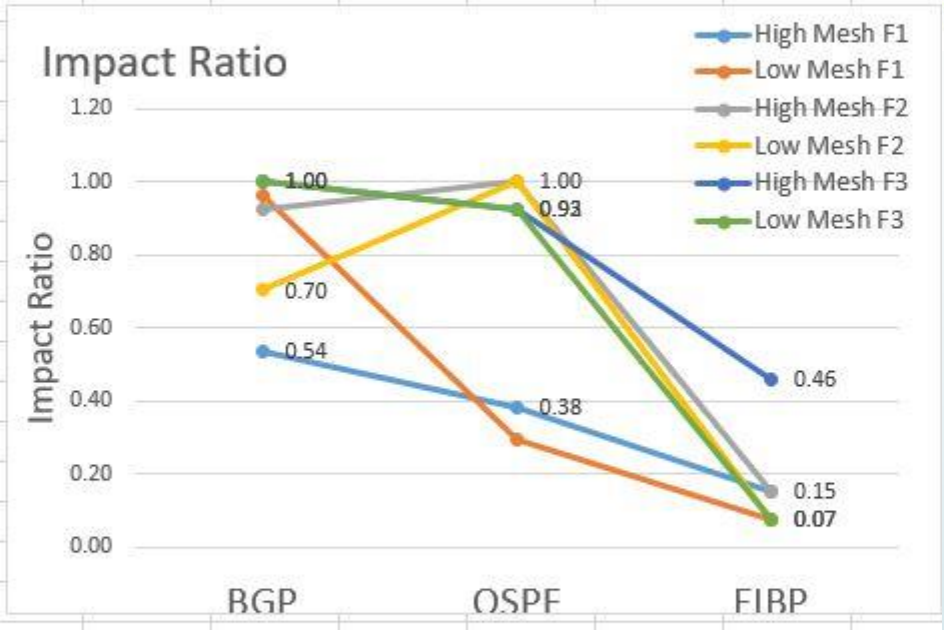
The Expedited Internet Bypass Protocol

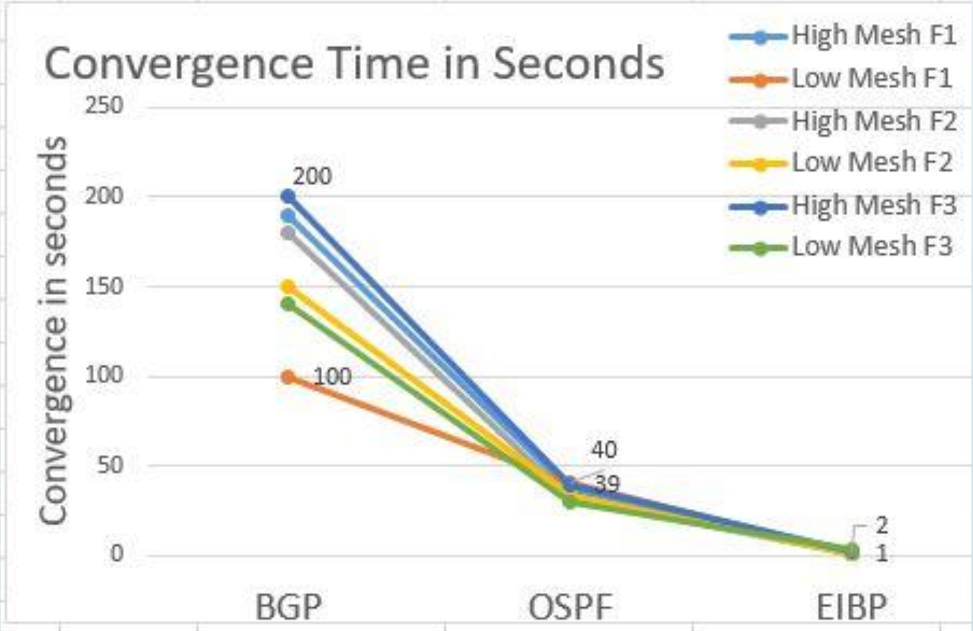
- EIBP for end to end IP (network or user) packet delivery
  - One protocol to route and forward
  - No routing protocols required
  - Avoids routing tables and global dissemination of routes
    - Scalable !!



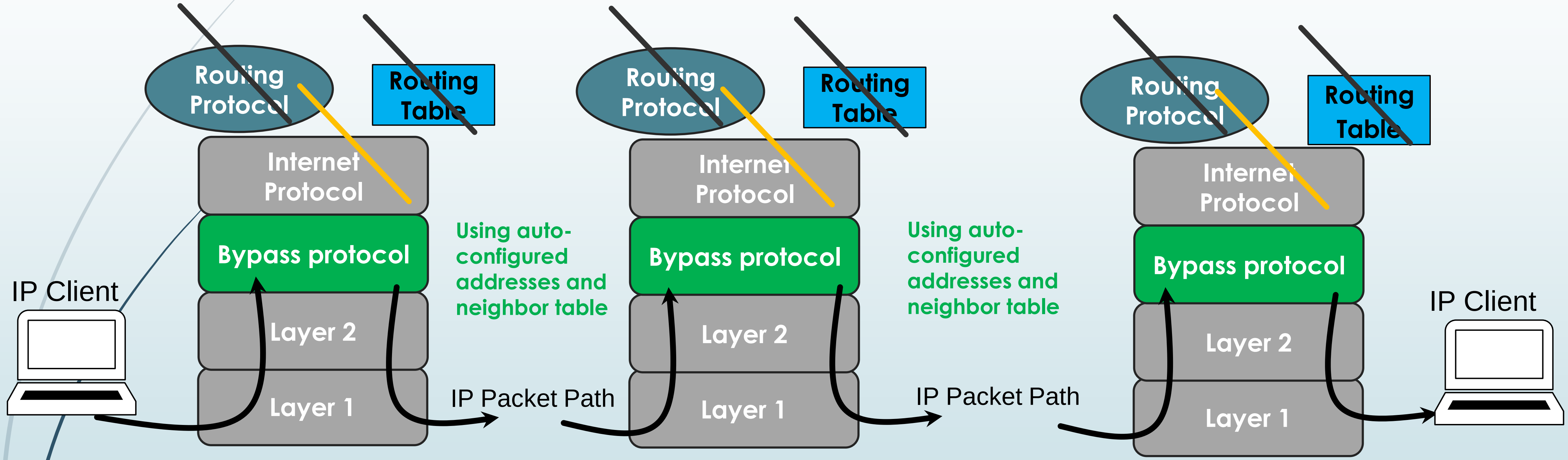
The Expedited Internet Bypass Protocol

- ***Auto-configured addresses provide routing***
  - Routers store multiple routing paths
  - Topology changes have local impact
  - Avoids instability in routing
- Extremely Fast Recovery on component Failures



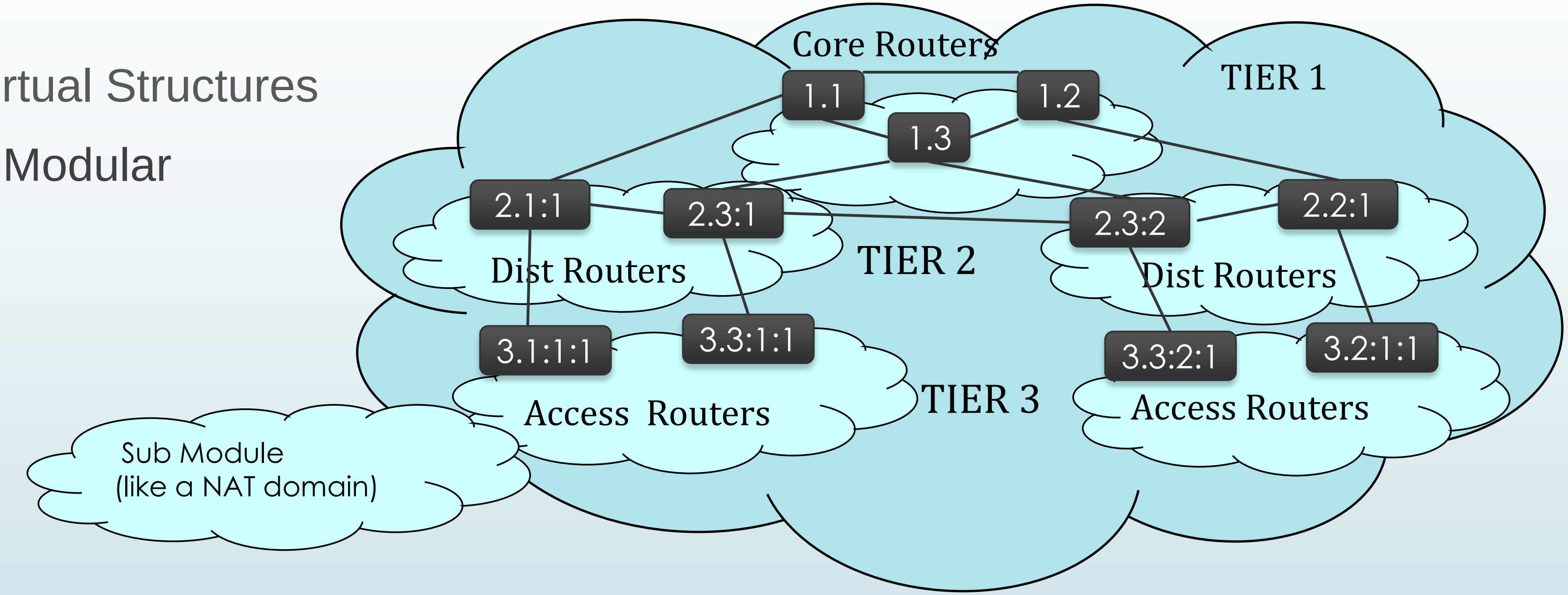


The Expedited Internet Bypass Protocol



Routing with EIBP

- Physical or Virtual Structures
- Scalable and Modular
- Avoids loops



- Example – Three Tier Structure in Autonomous System

EIBP Implementation Details

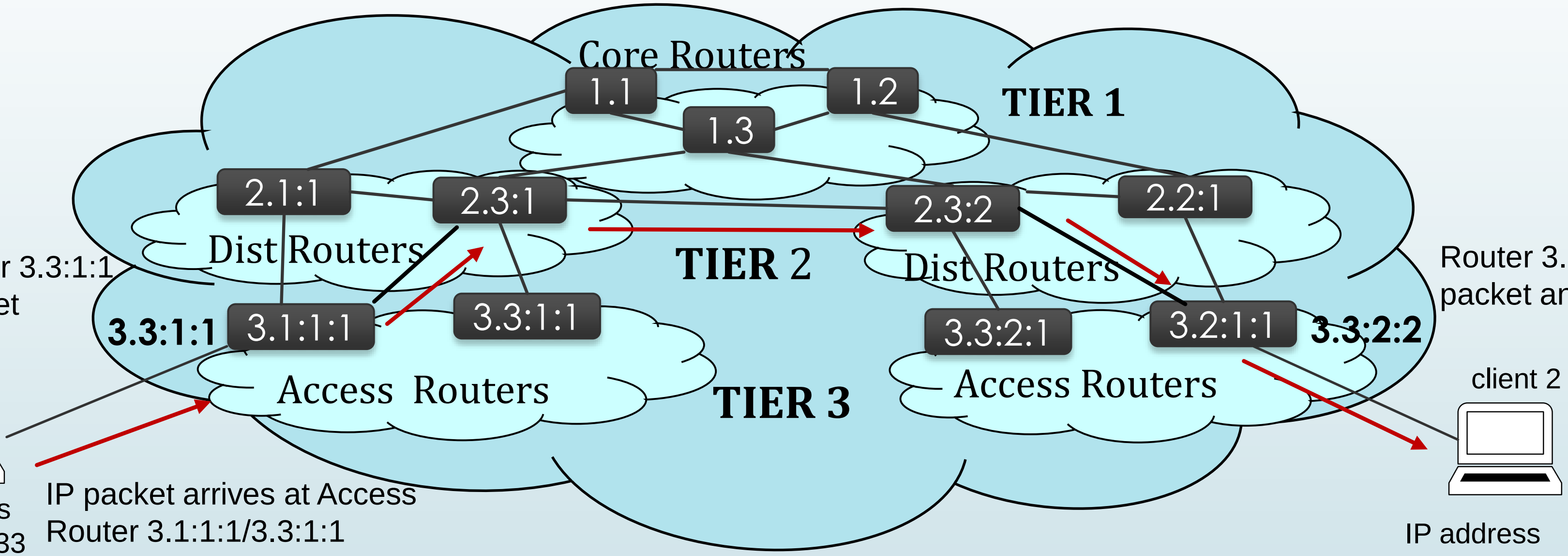
- Nirmal Shenoy, Shashank Rudroju and Jennifer Schenider, " An Emergency Internet Bypass Lane Protocol", High Performance Computing and Communications (HPCC-2018) Exeter, England, UK, 28-30 June 2018
- Nirmala Shenoy, Supriya Kharade, Shashanki Rudroju, Jennifer Schenider, " Validation of a New Internet Bypass Lane Protocol", at IEEE International Conference on Computer Communications (INFOCOMM), At the Computer and Networking Experimental Research using Testbeds, 15-19 April 2018 Honolulu, HI, USA

Routing with EIBP Addresses

(ANIMATED SLIDE)

Router 2.3:1 identifies 2.3:2 as neighbor closest to destination router 3.3:2:2 and forwards

Router 2.3:2 forwards to 3.3:2:2



EIBP at access router 3.3:1:1 captures the IP packet

Router 3.3:2:2 de-encapsulates IP packet and sends to client 2

IP address 10.11.22.33

IP packet arrives at Access Router 3.1:1:1/3.3:1:1

IP address 10.22.33.11

10.22.33.11	10.11.22.33	payload

IP packet from client 1 to client 2

Access Router looks up structural address of access router connecting client 2, which is 3.3:2:2

Encapsulates IP packet in EIBP header -

3.3:1:1	3:3:2:2	10.22.33.11	10.11.22.33	payload

Identifies neighbor 2.3:1 as the next router closest to destination

Sends encapsulated packet to distribution router 2.3:1

EIBP Implementation

- *Implemented as a C-code that operates below the Internet Protocol*
  - *Prototype Tested for intra-AS routing and forwarding*
  - *Compared with IP & BGP, IP & OSPF*
  - In Linux Systems (Ubuntu 16.04) in the GENI testbeds
- Code Available on gitlab
- Future plans -> include as extension to MPLS code
  - Towards deployment

Benefits

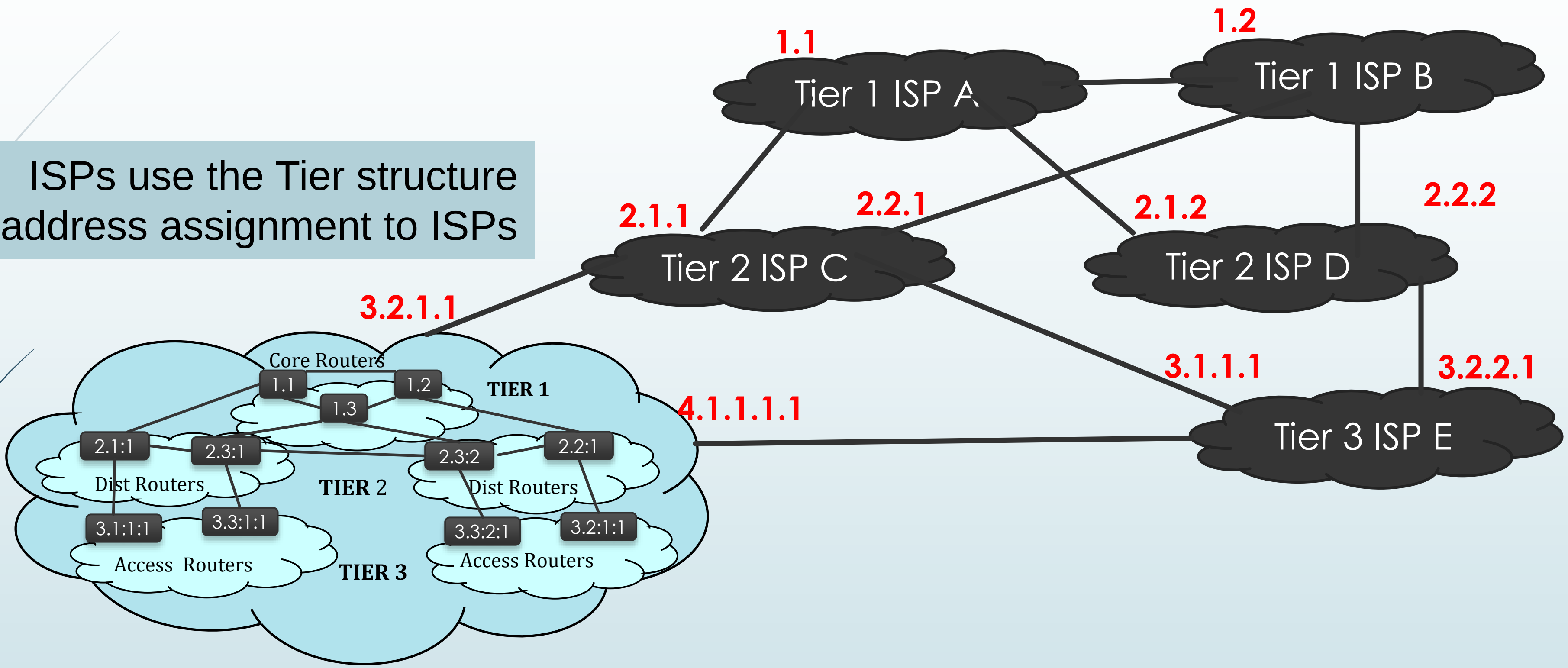
- Very low convergence and recovery times on failures
- Routing simplified
  - Integration of control and data planes
- Improved Security and Privacy for data transfers
- Improved Fault Tolerance (backup paths immediately available)
- Can include special headers for special packet handling
- Seamless interworking of intra-AS and Inter-AS operations
  - Current interworking with OSPF, iBGP and eBGP is very complex
- Scalable – routing base does not grow with network size
  - see performance results – later slides
- Deployment and migration with least impact on current IP implementations

Summary

- EIBP – transparent operation with current Internet protocols
- Efficient use of Internet infrastructure
  - Normal traffic uses IP
  - Special handling – invoke EIBP
- Improvements with EIBP
  - Significant performance improvement
  - Reduced complexity
  - Fast convergence
  - Scalable
- EIBP can be extended for inter-AS operations

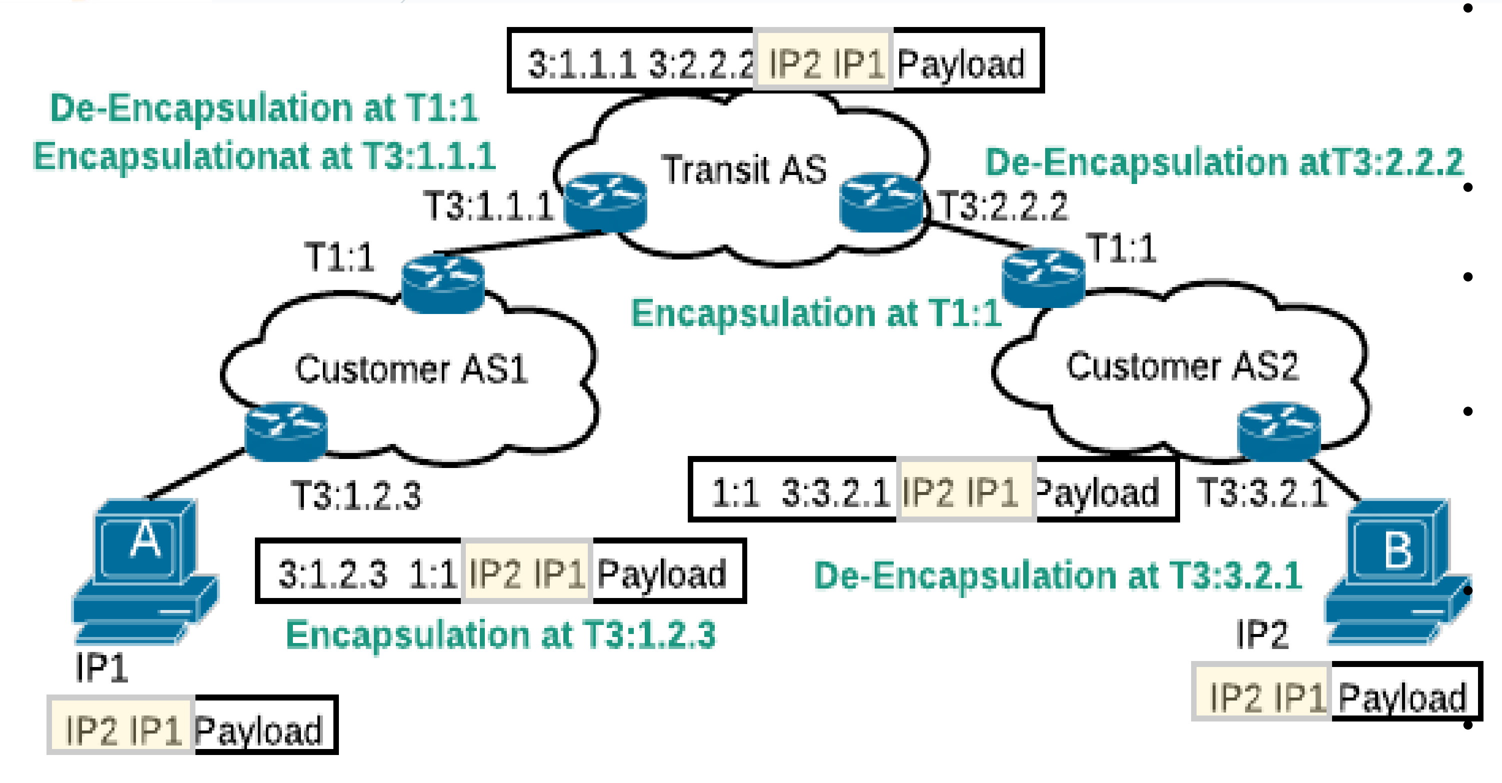
How about Inter-AS with EIBP

ISPs use the Tier structure
Auto address assignment to ISPs



Inter-AS forwarding next slide

Extending to inter-AS



A single protocol for intra-AS and inter-AS
No iBGP and complex interworking with multiple routing protocols

- System A sends an IP packet to System B.
- At access router T3:1.2.3 IP packet is encapsulated and sent to the core /border router as destination B' address IP2 is not in AS1.
- Packet reaches T1:1, it forwards the packet to T3:1.1.1 at the transit AS.
- At the transit AS, the access routers have the AS IP addresses that the transit AS is connected to.
- The access routers also have a map of the AS IP addresses (that the transit AS connects) mapped to the structured address of the access routers.
- Router T3:1.1.1 will encapsulate the IP packet with new header and the packet will be delivered to router T3:2.2.2,
- T3:2.2.2.2 will de-encapsulate and send to T1:1 at Customer AS2.
- The packet is re-encapsulated at T1:1 at Customer AS2, and delivered to access router T3:3.2.1
- Access router de-encapsulates and deliver to System B

THANKS

QUESTIONS

Informational

EIBP details

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Prototype Tests on GENI Testbed

Performance Compared with IP&OSPF and IP&BGP

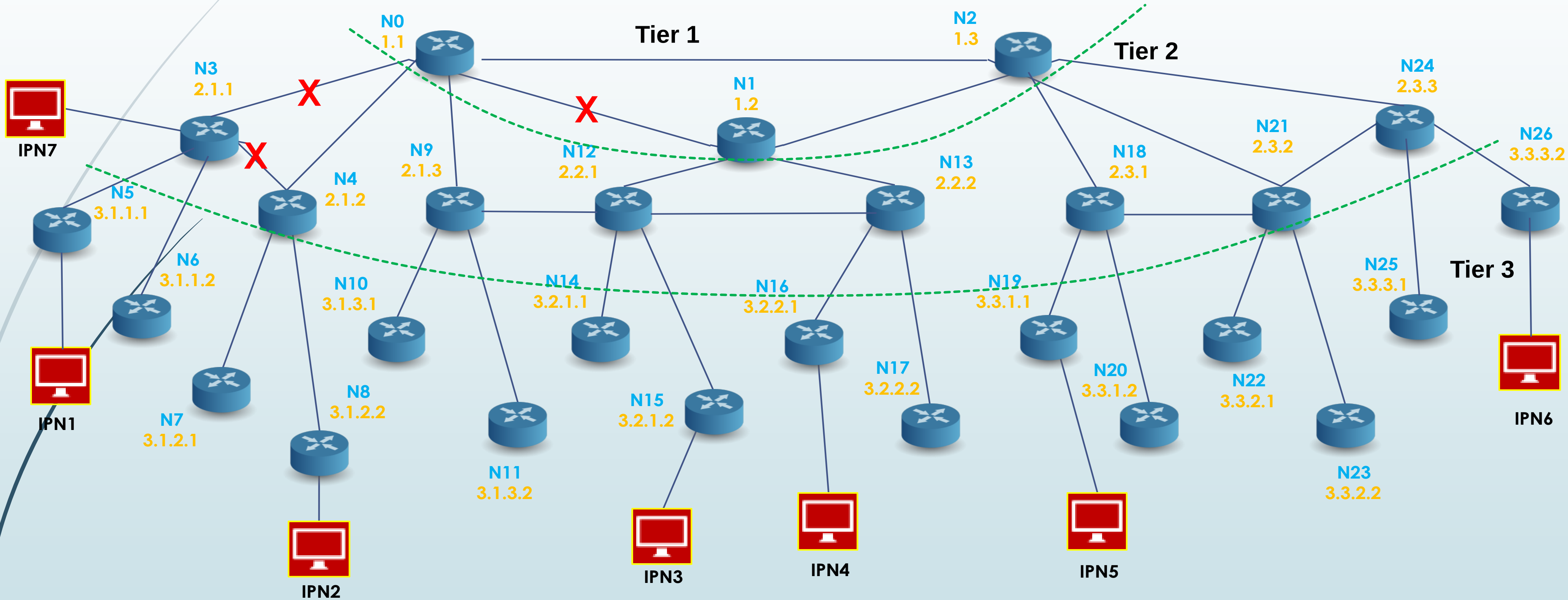
What is the GENI testbed?

GENI (Global Environment for Network Innovations) provides a virtual laboratory for networking and distributed systems research and education. It is well suited for exploring networks at scale, thereby promoting innovations in network science, security, services and applications. GENI allows experimenters to:

- **Obtain compute resources from locations around the United States;**
- **Connect compute resources using Layer 2 networks in topologies best suited to their experiments;**
- **Install custom software or even custom operating systems on these compute resources;**
- **Control how network switches in their experiment handle traffic flows;**
- **Run their own Layer 3 and above protocols by installing protocol software in their compute resources and by providing flow controllers for their switches.**

→ https://www.geni.net/about-geni/what-is-geni/

Prototype Evaluation on GENI Test Bed
27 Routers (Low Mesh) with IP Clients

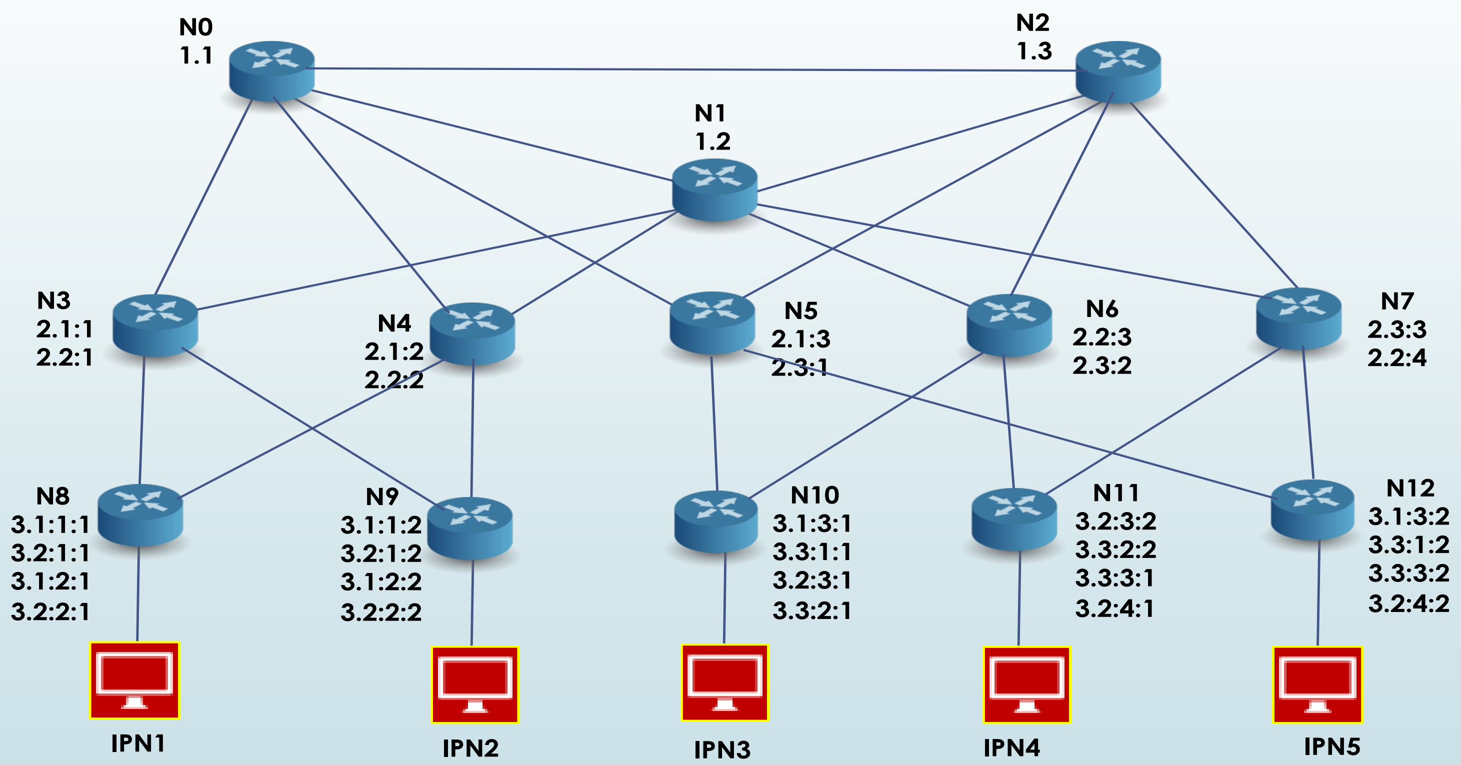


27 ROUTER TEST TOPOLOGY ON GENI TESTBED

X – Failure Points (only one address shown)

This is one of many tests conducted. Please check Nirmala Shenoy, Shashank Rudroju and Jennifer Schneider, " An Emergency Internet Bypass Lane Protocol", High Performance Computing and Communications (HPCC-2018) Exeter, England, UK, 28-30 June 2018

13 Routers (Highly Meshed) with IP Clients



27 ROUTER TEST TOPOLOGY ON GENI TESTBED

Performance tested

- Single Link Failures
- Convergence time – network stabilization time after a link failure
  - Focus on protocol recovery time
- Impact ratio – number of routers that changed their routing tables
- Routing table size

- Future work:
  - Packets lost during convergence
  - Control overhead generated during convergence
  - Multiple failures
  - Router failures

Failure Recovery and Convergence

	FAILURE BETWEEN N3 AND N4		FAILURE BETWEEN N0 AND N1		FAILURE BETWEEN N0 AND N3	
	Convergence (seconds)	Impact Ratio	Convergence (seconds)	Impact Ratio	Convergence (seconds)	Impact Ratio
BGP	FD+100 (PR)	26/27	FD+100 (PR)	19/27	FD+100 (PR)	27/27
OSPF	FD+30 (PR)	8/27	FD+30 (PR)	27/27	FD+30 (PR)	25/27
EIBP	1	2/27	1	2/27	3	5/27
FD – Failure Detection, PR – Protocol Recovery						

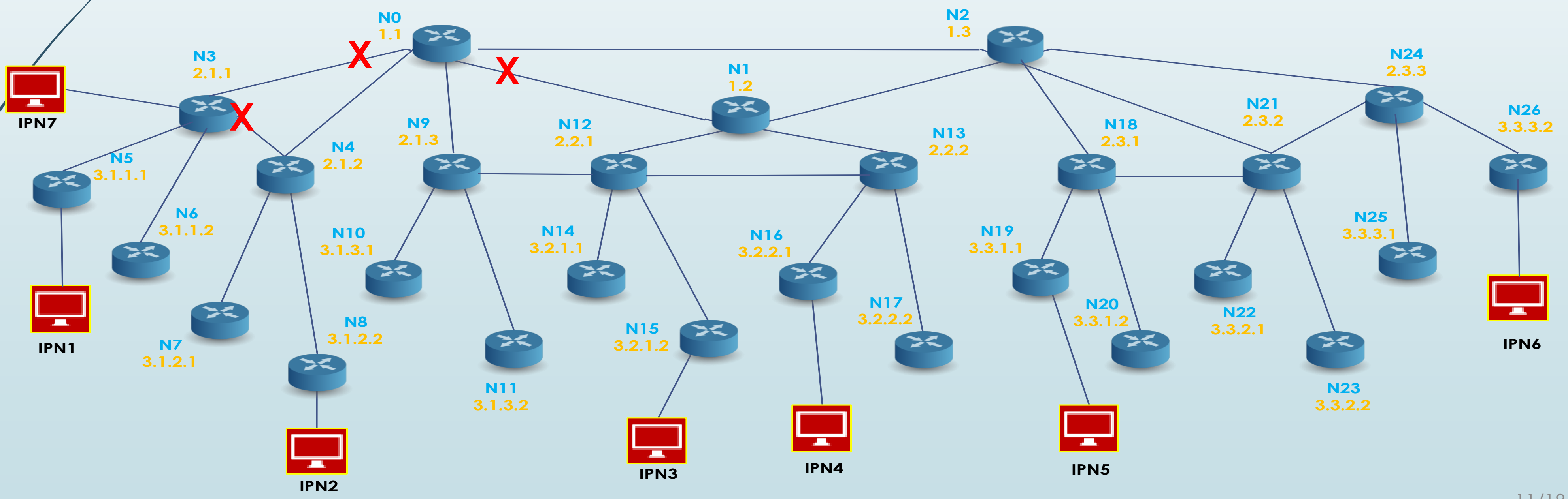


Figure 6: Sparsely Meshed Topology with 27 routers

Routing Table Sizes

Protocol	Routing Table Size	
BGP	93	multiple backup
OSPF	83	at least 1 backup
EIBL	5	Neighbor table size, multiple backup