An Expedited Internet Bypass Protocol – Improving Internet Performance

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Agenda

- Growing complexity in Internet operations
  - Escalating Proprietary Solutions & Infrastructure Costs
- How to improve Internet performance?
  - A Cost Effective – Low Complexity Solution
  - The Expedited Internet Bypass Protocol (EIBP)
- Performance of EIBP vs IP&BGP, IP&OSPF
- Discussions / Questions

Growing Internet Challenges

- Number of Internet Users and Networks continue to grow
- Applications using Internet continue to grow
- Internet today
  - IP to forward Internet packets, BGP and OSPF provide routing information
  - Are they scalable?
  - Are they addressing specific application needs?
  - How about security, privacy, communications during an emergency?

How to Address the Challenges

- Improve the Internet? – We are trying
- Replace the Internet? ……….
- Bypass the Internet – demonstrated
  - The Expedited Internet Bypass Protocol (EIBP)
  - Usage: Turn on bypass services for specific IP users (networks) when needed

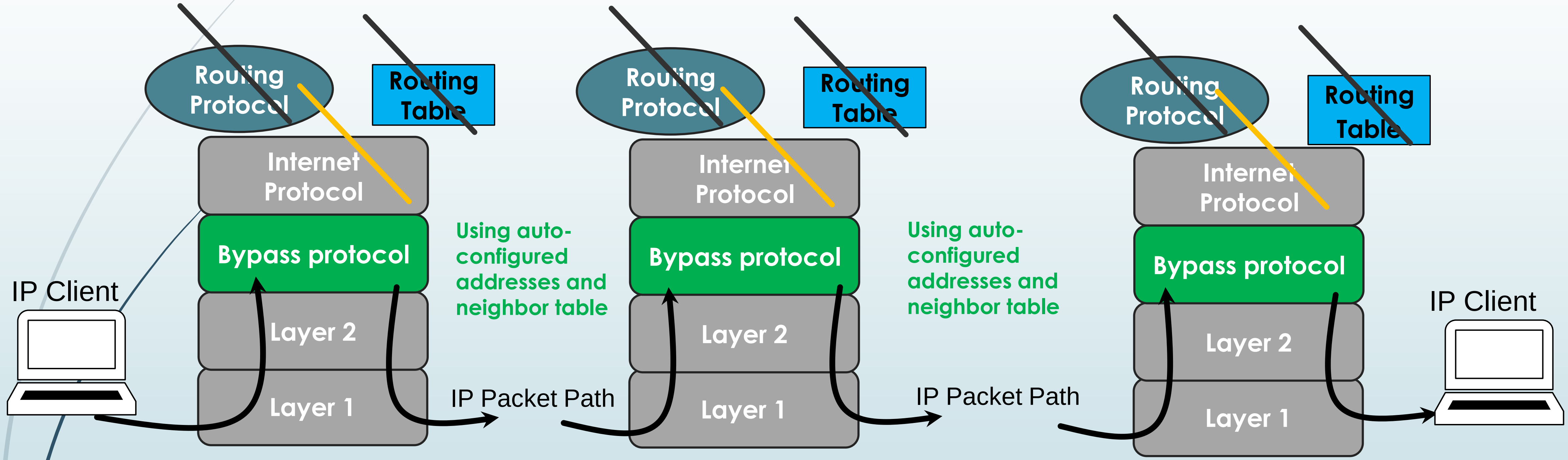
The Expedited Internet Bypass Protocol

- EIBP for end to end IP (network or user) packet delivery
  - A single protocol to route and forward
  - No routing protocols required
  - Avoid routing tables and global dissemination of routes
- ***Auto-configured addresses at routers provide routing information***
  - Routers store multiple routing paths
  - Topology changes have local impact
- Extremely Fast Recovery on component Failures

The Expedited Internet Bypass Protocol

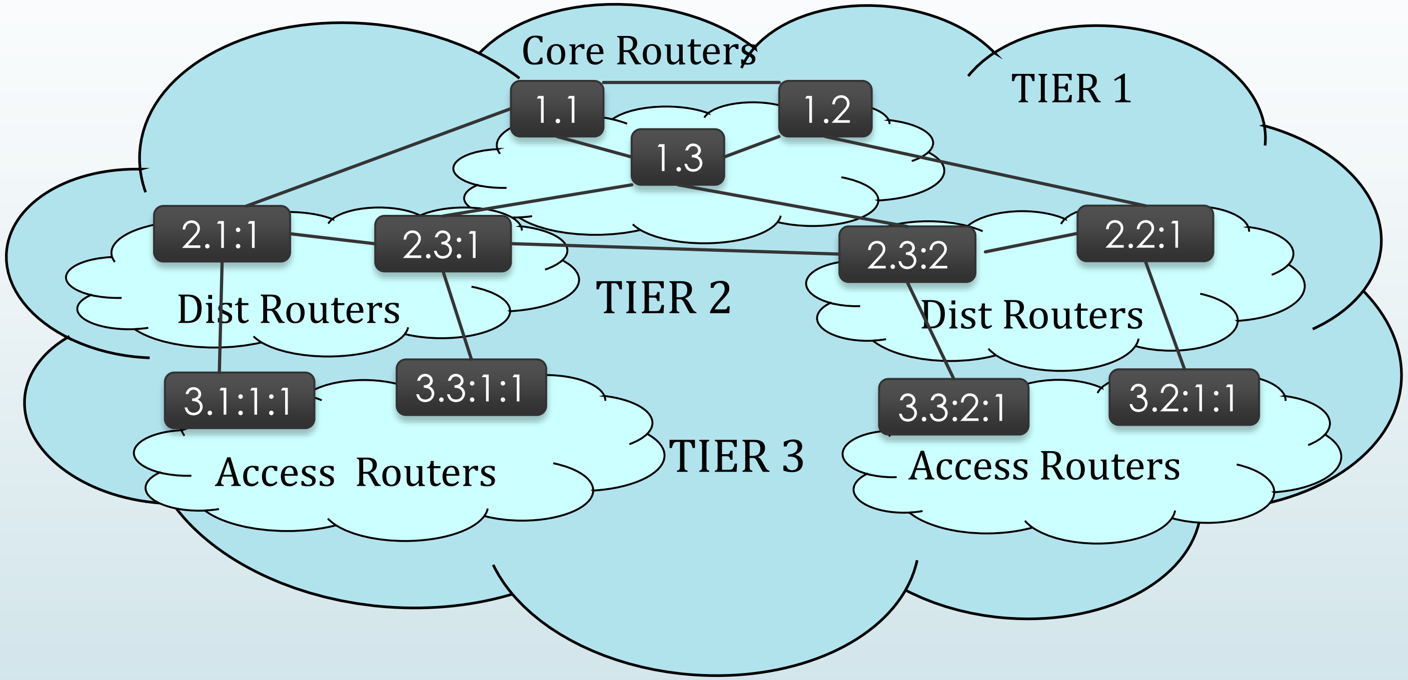
- Expedites forwarding of selected traffic –
  - EIBP traffic flows below IP, hence IP traffic is avoided
    - Also bypasses layer 3 security threats
  - EIBP operations are transparent to operations at Layer 3

The Expedited Internet Bypass Protocol



Routing with EIBP

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



- Example – Three Tier Structure in Autonomous System

Routing with EIBP Addresses

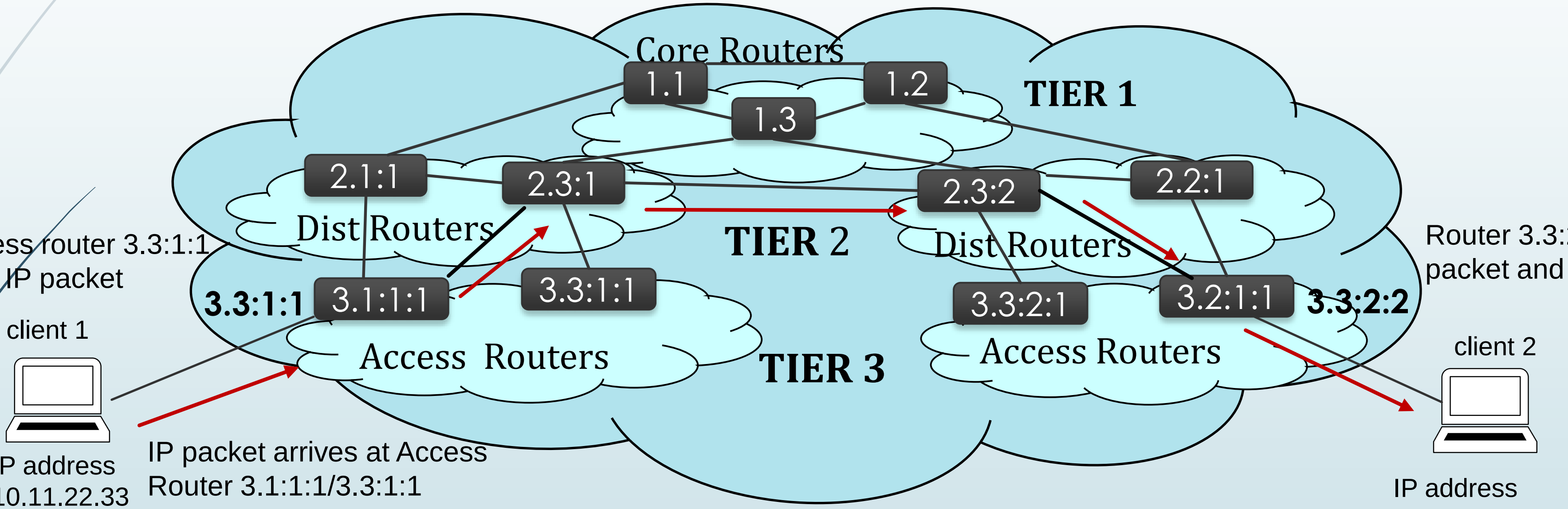
(ANIMATED SLIDE)

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

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

Bypass Protocol Implementation

- *Implemented as a C-code that operates below the Internet Protocol*
  - *Prototype Tested for intra-AS routing and forwarding*
  - In Linux Systems (Ubuntu 16.04) in the GENI testbeds

- Code Available on gitlab

http://www.rit.edu/news/story.php?id=61939

Prototype Tests on GENI Testbed

Performance Compared with IP&OSPF and IP&BGP

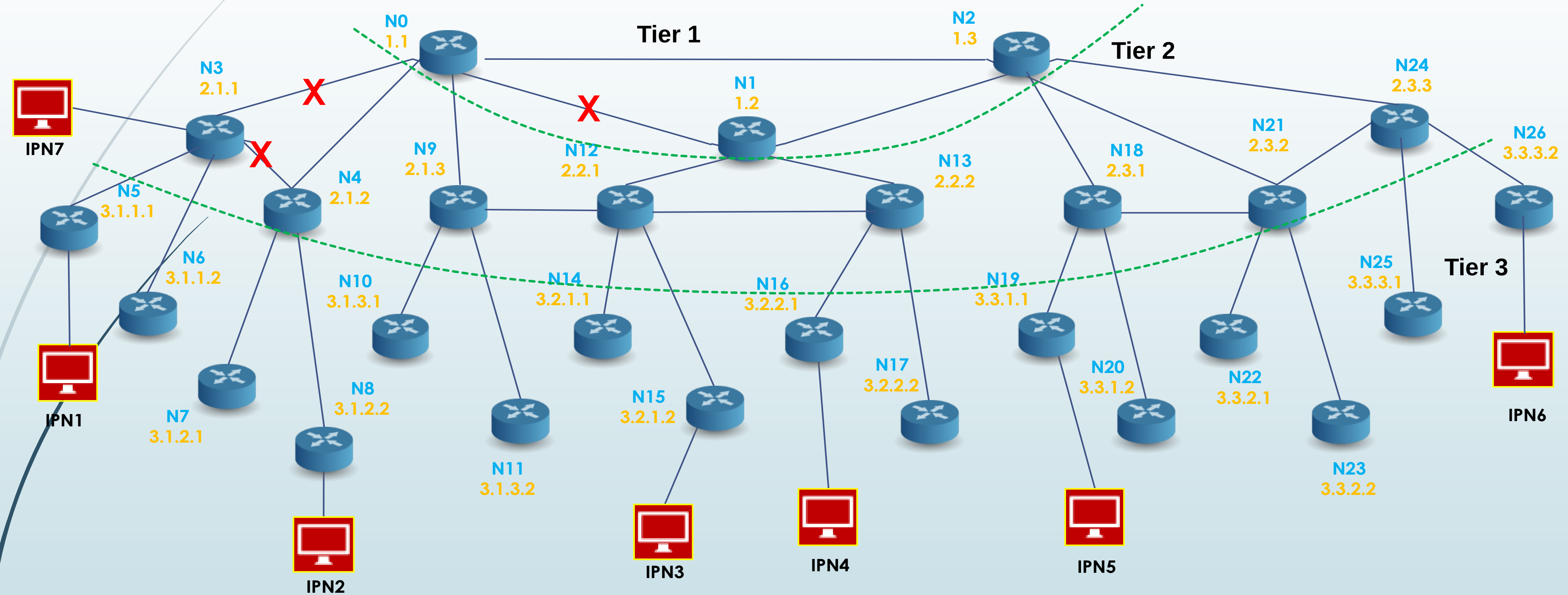
What is the GENI testbed?

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
17 Routers with IP Clients



17 NODE 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

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						

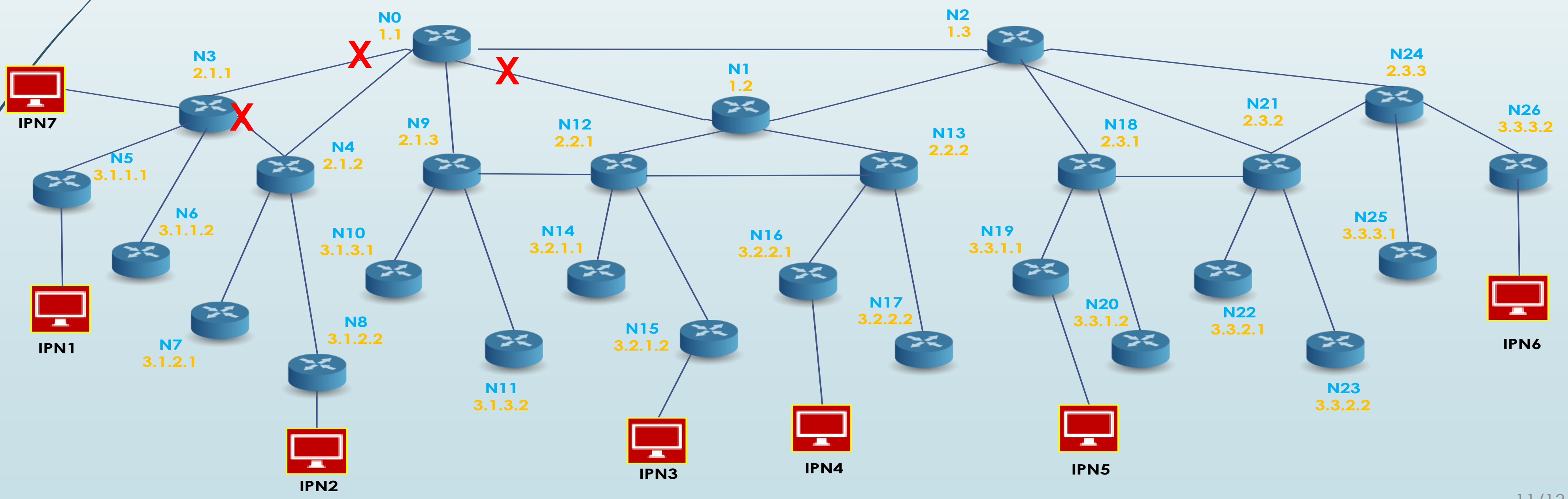


Figure 6: Sparsely Meshed Topology with 27 routers

Routing Table Sizes

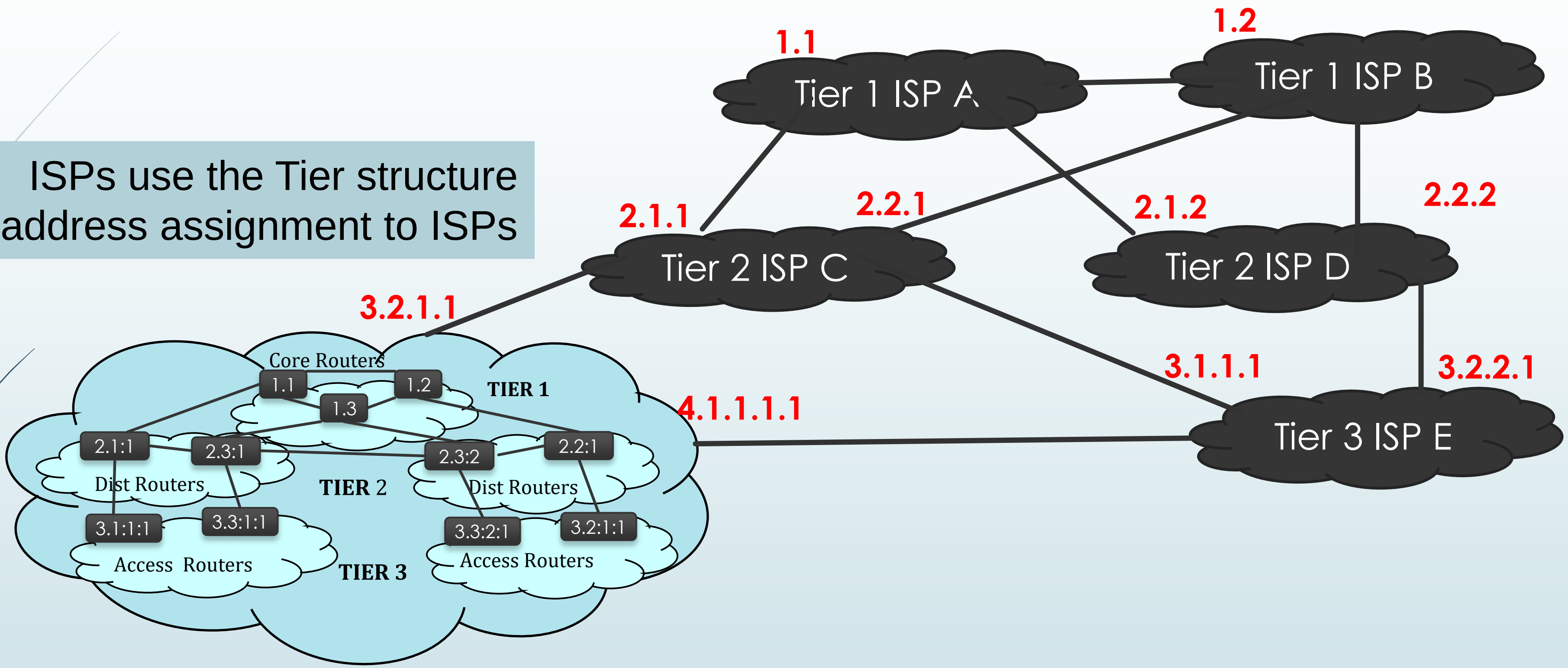
Protocol	Routing Table Size	
BGP	93	multiple backup
OSPF	83	at least 1 backup
EIBL	5	Neighbor table size, multiple backup

Benefits

- Several magnitudes in recovery times on failures
- Routing simplified
  - Integration of control and data planes
- Improved Security and Privacy for data transfers
- Improved Fault Tolerance
- Seamless interworking of intra-AS and Inter-AS operations
  - Investigative studies
- Deployment and migration with least impact on current IP implementations

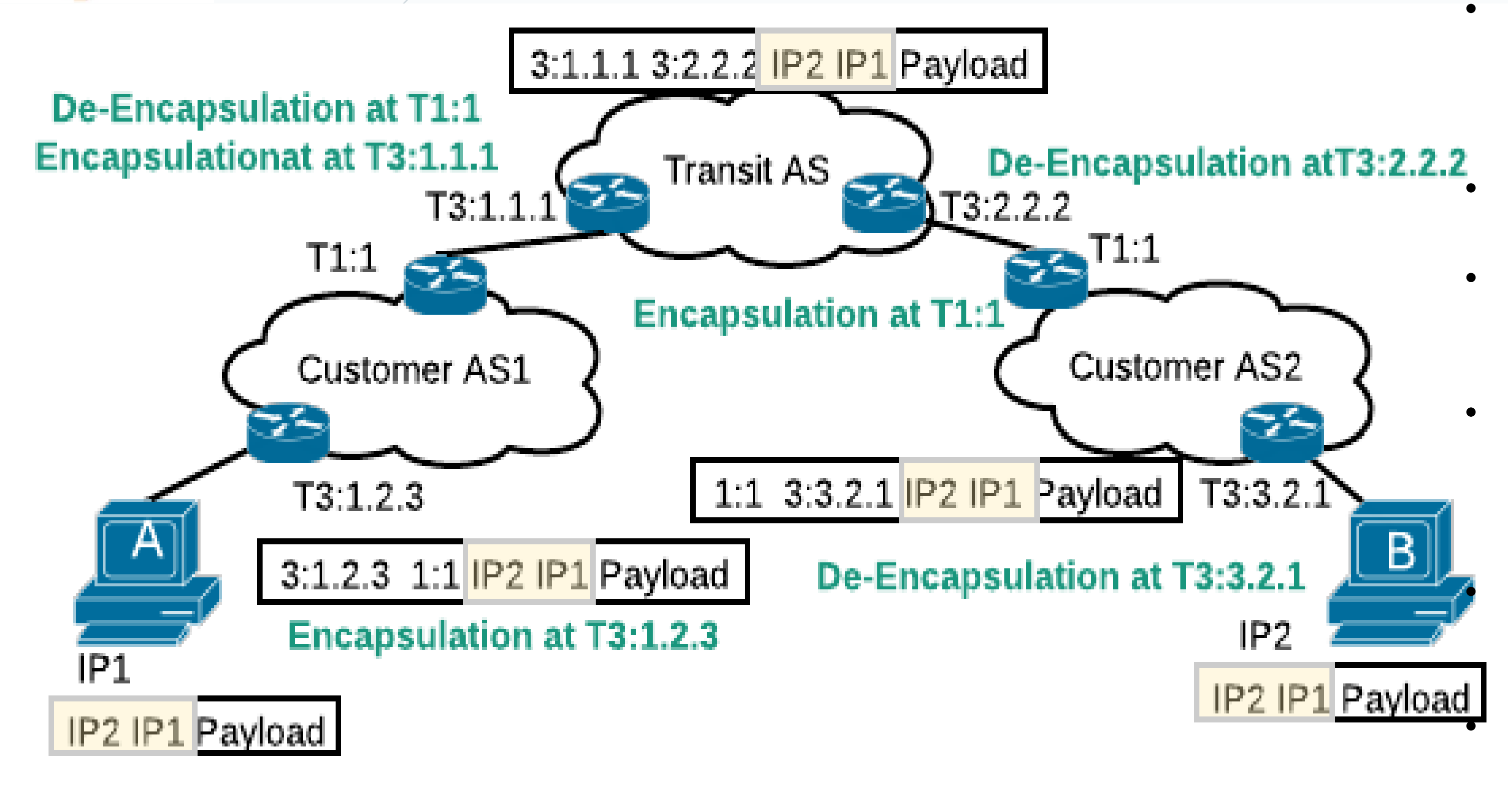
Inter-AS with EIBP

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

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

THANKS

QUESTIONS