

École Pour l'Informatique et les Techniques Avancées – EPITA

BSc L1 – 14 May 2024

Course: Introduction to Computer Networks

Introduction to Computer Networks

| Date & Time | No. | Topics | Duration (hours) |
|----------------------------|-----|---|------------------|
| Fri 19/04/24 – 10:00–13:00 | 1 | Primer, Network protocols, types, topology, architecture | 3 |
| Fri 26/04/24 – 10:00–13:00 | 2 | Network models, TCP/IP model, Packet switching | 3 |
| Sat 27/04/24 – 10:00–13:00 | 3 | Physical Layer (Function, Signals, Modulation, Multiplexing, Transmission media & Hardware, Optical networks) | 3 |
| Sat 27/04/24 – 14:00–17:00 | 4 | Data Link Layer (Function, Framing, Protocols, Flow control, Access control, Error correction, Hardware) | 3 |
| Fri 03/05/24 – 14:30–17:30 | 5 | Network Layer (Function, IP addressing and subnets) | 3 |
| Sat 04/05/24 – 10:00–13:00 | 6 | Network Layer (Routing algorithms and protocols), Internet Control Message Protocol | 3 |
| Tue 14/05/24 – 16:30–19:30 | 7 | Network Layer (IGP & EGP), Autonomous System, Border Gateway Protocol | 3 |
| Wed 15/05/24 – 14:30–17:30 | 8 | Transport Layer (Function, Flow and congestion controls, Protocols) | 3 |
| Thu 16/05/24 – 11:15–13:15 | 9 | Application Layer (Function, Protocols) | 2 |

Introduction to Computer Networks

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|----------------------------|-----|--|------------------|
| Fri 17/05/24 – 14:00–17:00 | 10 | Cross-layer process: Access Control Lists | 3 |
| Sat 18/05/24 – 14:00–17:00 | 11 | Cross-layer process: Network Address Translation | 3 |
| Fri 24/05/24 – 10:00–13:00 | 12 | Review / Open-session | 3 |
| Total | | | 35 |
| Fri 31/05/24 – 14:30–15:30 | | EXAM | 1 |

GRADING criteria :

- Class participation comprising **attendance & reactivity**): 10%
- **Exercises** (practical work): 40%
- Final evaluation (**Quiz & Exercises**): 50%

i Check policies in the course outline

Lecture 1 1 Outline

- ▶ **IGP & EGP**
 - **Autonomous System (AS)**
 - **IGP vs EGP**
- ▶ **Border Gateway Protocol (BGP)**
 - Introduction
 - BGP and Internet
 - BGP visualizations
 - Class exercise 12

Interior Gateway Protocols (IGP) & Exterior Gateway Protocols (EGP)

| Interior Gateway Protocols | | | | Exterior Gateway Protocols | |
|-----------------------------------|-------|------------------------------|--------|----------------------------|----------------|
| Distance Vector Routing Protocols | | Link State Routing Protocols | | Path Vector | |
| Classful | RIP | IGRP | | EGP | |
| Classless | RIPv2 | EIGRP | OSPFv2 | IS-IS | BGPv4 |
| IPv6 | RIPng | EIGRP for IPv6 | OSPFv3 | IS-IS for IPv6 | BGPv4 for IPv6 |

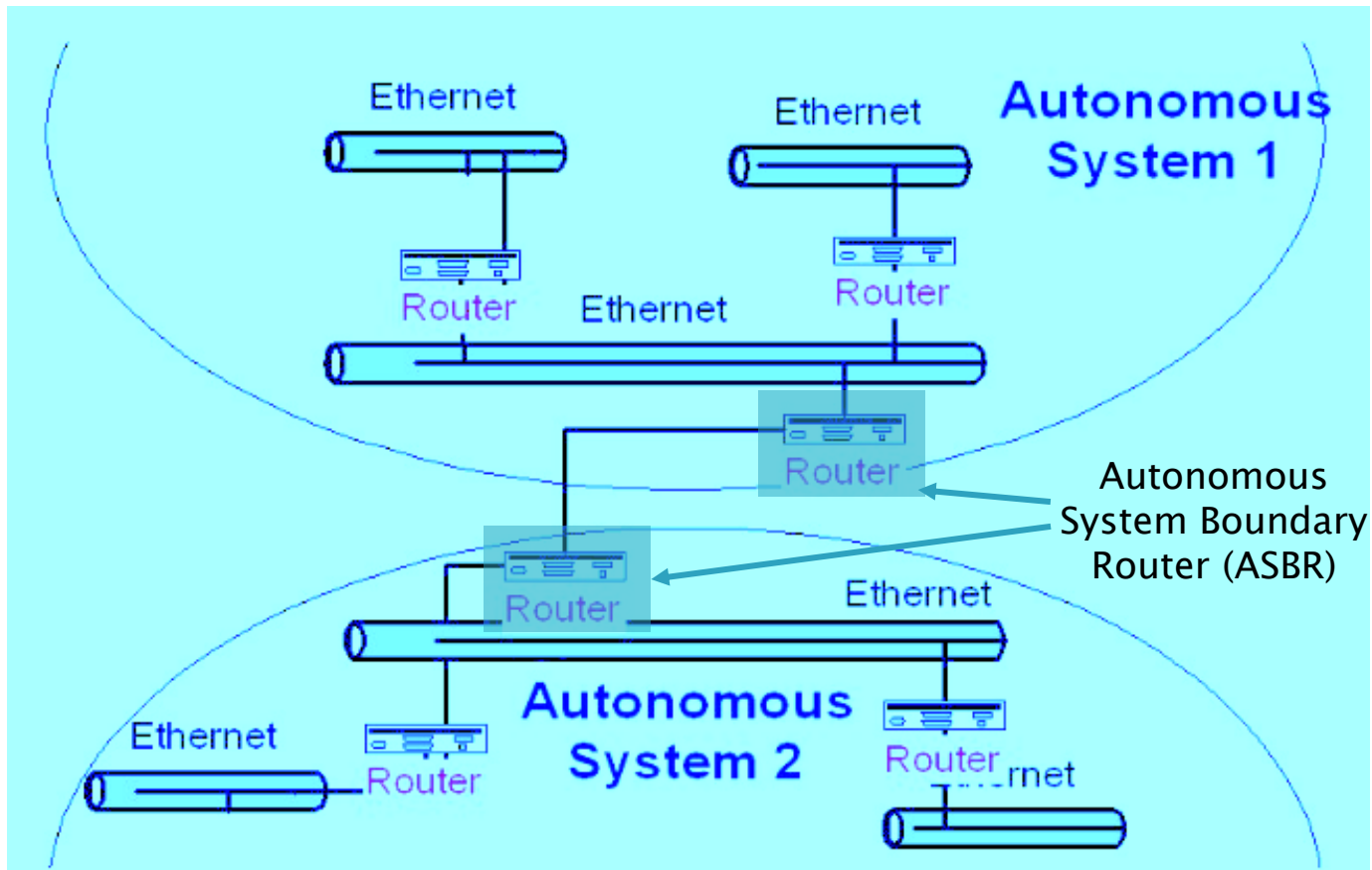
i Legacy

Autonomous System (AS)

- ▶ A network under the control of one or more network operators on behalf of a single administrative entity (e.g., ISP, ...)
 - Presents a common, clearly defined policy to the internet (as defined in RFC 1771, RFC 1930)
 - Every AS is assigned with a unique 16/32 bit AS number by IANA
- ▶ Types:
 - Multihomed: maintains connection to more than one
 - Stub: connected to only one AS (single-homed)
 - Transit: provides connections through itself to other AS's

Autonomous System (AS) (cont.)

If AS 1 is not connected to any other AS than AS 2, then AS 1 is Single-homed (or a Stub)



If AS 2 connects to AS 3, then AS two is Multihomed AS (may or may not act as Transitive)

Autonomous System Number (ASN) assignment

To obtain ASN, from Regional Internet Registry (RIR) delegated by IANA, entity must meet the eligibility criteria set by the RIR

The screenshot shows the RIPE NCC website interface. At the top, the RIPE NCC logo is on the left, and a search bar with 'RIPE Database (Whois)' and 'Website' tabs is on the right. Below the header is a navigation bar with links: 'Manage IPs and ASNs', 'Analyse', 'Participate', 'Get Support', 'Publications', and 'About Us'. The main content area is titled 'Autonomous System Numbers' and contains the following text:

Autonomous System Numbers

We distribute ASNs according to policies by the RIPE community. Any individual or organisation can request ASNs, though a contractual agreement with the RIPE NCC will be required.

To request an AS Number, you will need to have a contractual agreement with the RIPE NCC. To do this you will either need to [become a member](#) or find a [sponsoring LIR](#) who will submit the request on your behalf.

[Request AS Number](#)

(authentication required)

Here is the [information that will be required](#) for your request.

In case you represent a lot of members and you would like to automate the request process, you can use the [Resource Request API](#).

Request Evaluation

We will evaluate your request according to the applicable RIPE policies and RIPE NCC procedures. We will also check against the EU sanctions list – if you or your organisation is found to be under sanctions, the resources request will not be approved.

Created: 23 Dec 2010 - Last updated: 07 Apr 2021 — [AS NUMBERS](#), [RESOURCE MANAGEMENT](#)

The sidebar on the left contains a list of links: 'Manage IPs and ASNs', 'IPv4', 'IPv6', 'AS Numbers' (selected), 'Request an AS Number', 'Reassigning Referenced AS Numbers', 'AS Number Clean up', 'RIPE Database', 'DNS', 'LIR Portal', 'Documentation for Resource Management', 'Resource Transfers and Mergers', 'Legacy Internet Resources', and 'Contact Registry Services'. The footer includes social media icons and a list of links: 'Home', 'Sitemap', 'Contact Us', 'Service Announcements', 'Privacy Statement', 'Legal', 'Cookies', 'Copyright Statement', and 'Terms of Service'.

Source: <https://www.ripe.net/manage-ips-and-asns/as-numbers/request-an-as-number>

IGP and EGP

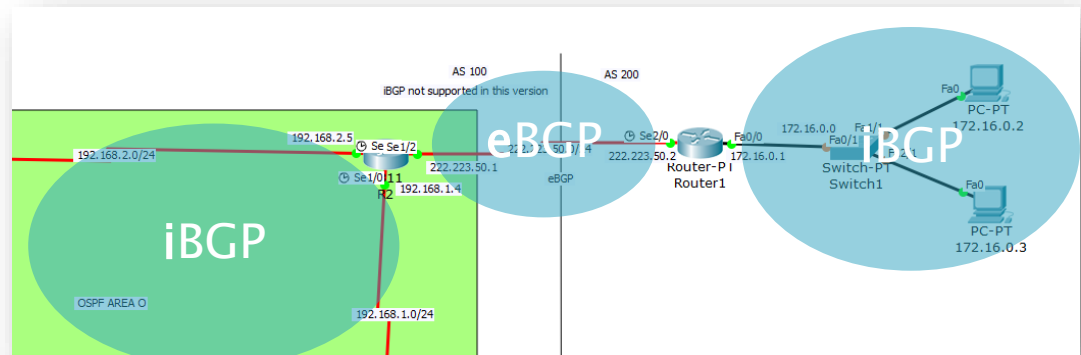
- ▶ Interior Gateway Protocols (IGP):
 - Used by Gateways to exchange routing information within (inside) an Autonomous System (AS)
 - E.g., corporate network, campus network, ISP network, ...
 - Operation: Distance vector (RIP, IGRP), Link state (OSPF, IS-IS)
- ▶ Exterior Gateway Protocol (EGP):
 - Used by Gateways to exchange routing information between (outside) Autonomous Systems
 - Routing path selection is based on:
 - Network policies
 - Network administrator configured rule-sets
 - Operation: Path vector (BGP)

Lecture 1 1 Outline

- ▶ IGP & EGP
 - Autonomous System (AS)
 - IGP vs EGP
- ▶ **Border Gateway Protocol (BGP)**
 - Introduction
 - BGP and Internet
 - BGP security concerns
 - Class exercise 12

Introduction

- ▶ Internet uses BGP4 (Border Gateway Protocol version 4):
 - Was published in 2006 as RFC 4271
 - eBGP (external BGP): exchange routing information b/w Autonomous Systems
 - iBGP (internal BGP): advertise routes within the same Autonomous System
- ▶ AS neighbors:
 - BGP Advertisement
 - IP/Prefix (reachability)
 - Update routing Paths

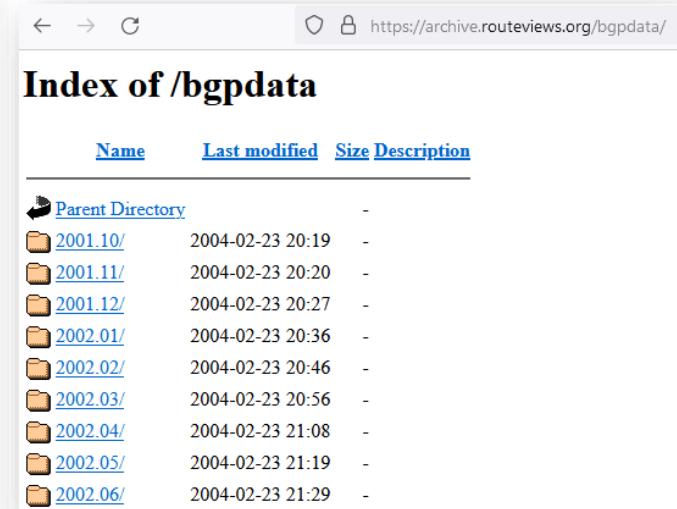


BGP and Internet

- ▶ BGP uses Path vector:

```
// Received at 15:32:43 (2.6 second delay)
{
  "timestamp": 1682688760.45,
  "peer": "193.203.0.75",
  "peer_asn": "40994",
  "id": "193.203.0.75-0187c810da820004",
  "host": "rrc05.ripe.net",
  "type": "UPDATE",
  "path": [40994, 174, 37288, 37288, 37288, 37288, 37288, 37288, 327992, 328184],
  "community": [[174, 21101], [174, 22012], [17152, 1]],
  "origin": "IGP",
  "announcements": [
    {
      "next_hop": "193.203.0.75",
      "prefixes": [
        "155.12.224.0/19"
      ]
    }
  ],
  "withdrawals": []
}
```

Source: <https://ris-live.ripe.net/>

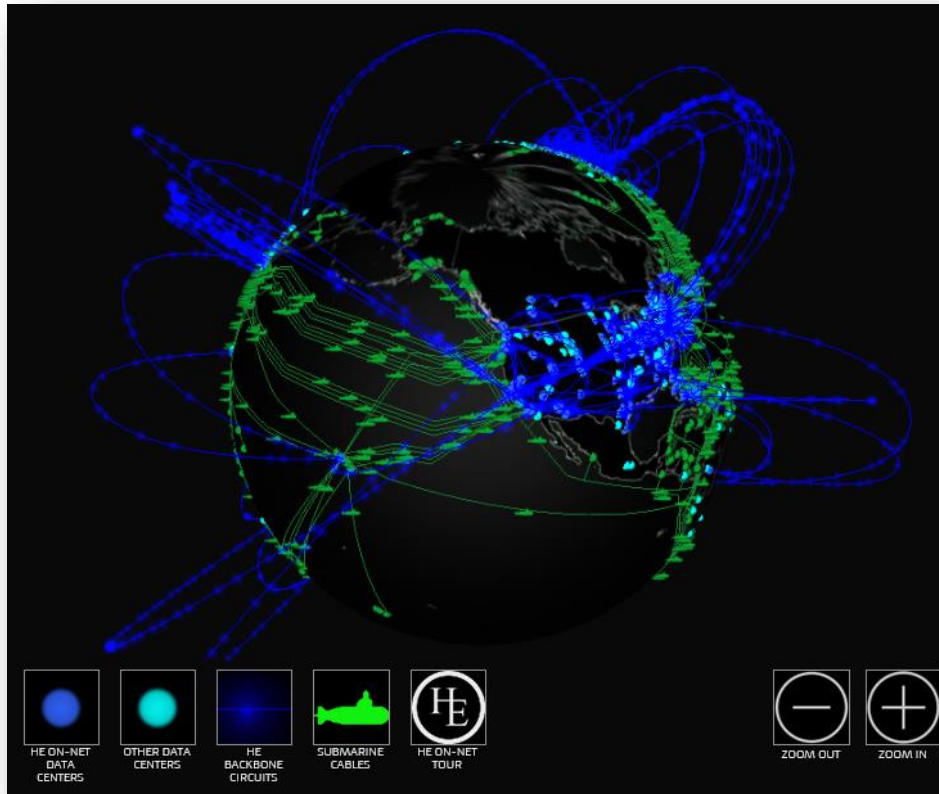


| Name | Last modified | Size | Description |
|----------------------------------|------------------|------|-------------|
| Parent Directory | - | - | - |
| 2001.10/ | 2004-02-23 20:19 | - | - |
| 2001.11/ | 2004-02-23 20:20 | - | - |
| 2001.12/ | 2004-02-23 20:27 | - | - |
| 2002.01/ | 2004-02-23 20:36 | - | - |
| 2002.02/ | 2004-02-23 20:46 | - | - |
| 2002.03/ | 2004-02-23 20:56 | - | - |
| 2002.04/ | 2004-02-23 21:08 | - | - |
| 2002.05/ | 2004-02-23 21:19 | - | - |
| 2002.06/ | 2004-02-23 21:29 | - | - |

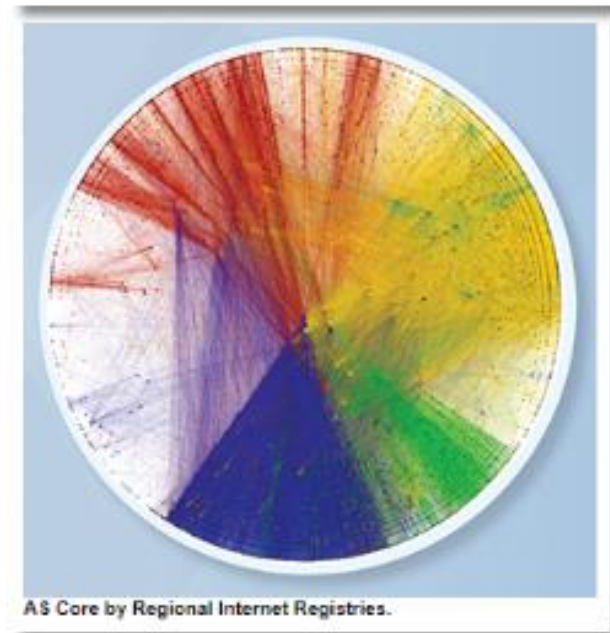
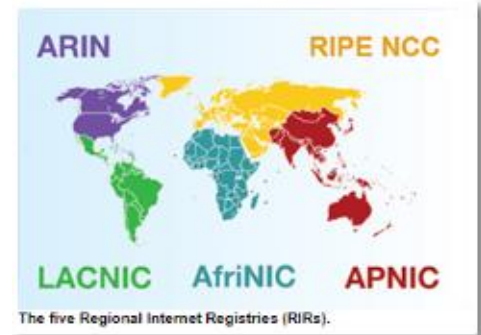
<https://archive.routeviews.org/bgpdata>

- ▶ Routing information includes the 'path' of AS's that are used to reach the destination
- ▶ Routing Table: Each entry contains the destination network, the next router and the path to reach the destination

BGP visualizations



Source: <https://www.he.net/3d-map>



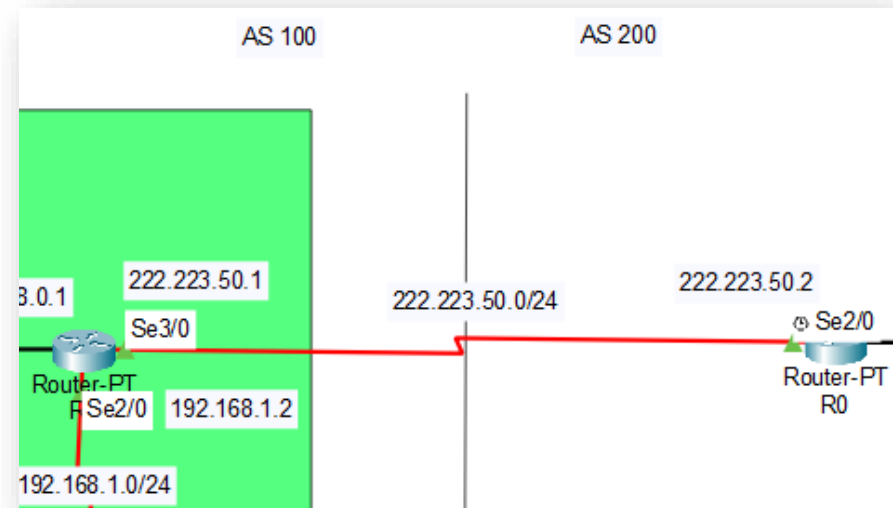
Source: http://www.caida.org/research/topology/as_core_network/2017/

Exercise 12: Practical work

► Use your existing cisco packet tracer file (from last class exercise):

1. Include all your existing topology in AS 100
2. Create another AS 200
3. Connect and configure AS 100 and AS 200 using BGP:
 1. Conf t
 2. router bgp 100 //AS number
 3. Network X.X.X.X mask Z.Z.Z.Z //Subnet mask, networks on ASBR that must be advertised
 4. neighbor X.X.X.X remote-as 200 //interface IP of the other AS ASBR interface
 5. ... //all neighbors internal or external that would need BGP (note: iBGP is not supported in CPT)
 6. Exit
4. Verify using PING and TRACERT/TRACEROUTE
5. Study the BGP path selection process:
<https://www.cisco.com/c/en/us/support/docs/ip/border-gateway-protocol-bgp/13753-25.html#anc2>

**Deadline: See 'Teams'
Assignment section**



Lecture 7 ends here

- ▶ Course Slides: Go to MS Teams:
'Introduction to Computer Networks – Spring 2024 | BSc'
-> Files section
- ▶ Send your questions by email:
mohammad-salman.nadeem@epita.fr
OR via direct message using MS Teams
- ▶ Thank You!