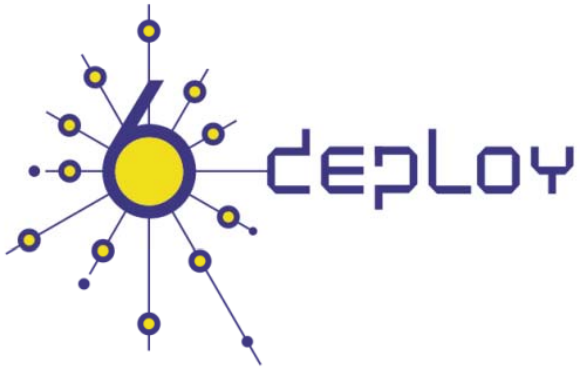
From IPv4 to IPv6

Workshop on Applications of Wireless Sensor Networks for Environmental Monitoring in Developing Countries

Trieste - 28 February 2011



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Agenda

1. Introduction
2. Networking Basics
3. Packet Forwarding
4. Routing protocols
5. IPv4 Addressing
6. IPv4 Internet History

1. Introduction

Introduction (1)

- Give an overview of IP data networks to understand where we are nowadays
- “Equalize” students knowledge (in order to)
- Be prepared for the IPv6 concepts we will see during the workshop

Introduction (2)

- We will focus on data networks
- The objective is to send groups of bits from one point to another
- Binary -> 0/1
- 1 Byte = 8 bits
- Digital Information -> represented by bits and grouped in bytes -> **divided** in network packets

2. Networking Basics

Networking Basics (1)

- Two options to send information:

1. **Circuits**: fixed paths, reserved resources, communication starts only when circuit is established (example: telephone)
2. **Switching**: paths can vary, shared resources (best effort), communication can start at any moment (example: postal mail, Internet)

Packet switching is much more efficient and flexible

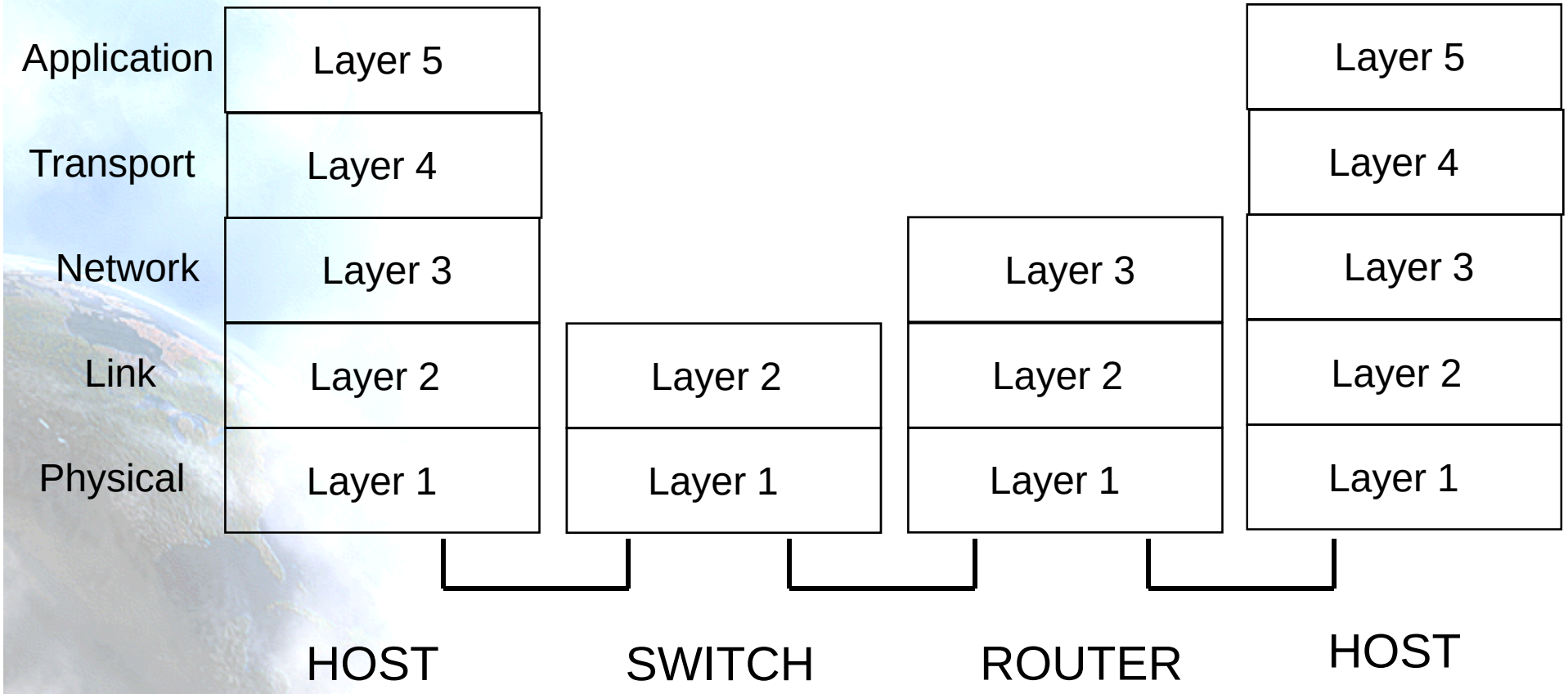
Networking Basics (2)

- Let's define things:

1. Layered model: physical, link, network, etc.
2. Node, host, router, server
3. Addresses: link layer, network layer
4. **Protocol**: definition of the format and order of messages exchanged between two or more communicating entities, as well as the actions taken on the transmission and/or reception of a message or other event

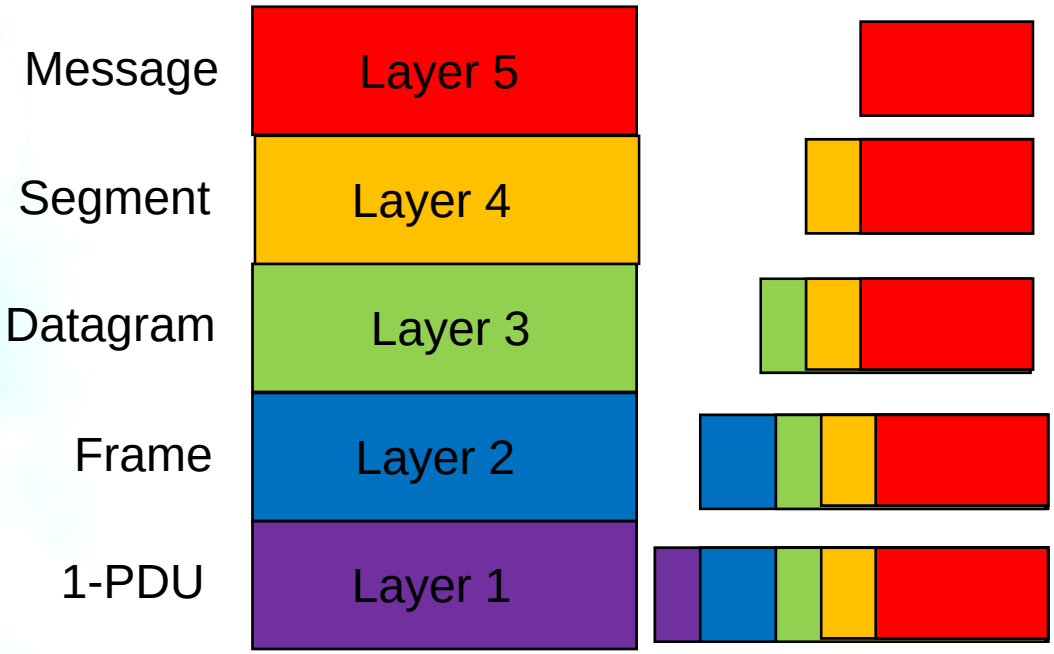
Networking Basics (3)

- TCP/IP layered model -> Used in Internet



Networking Basics (4)

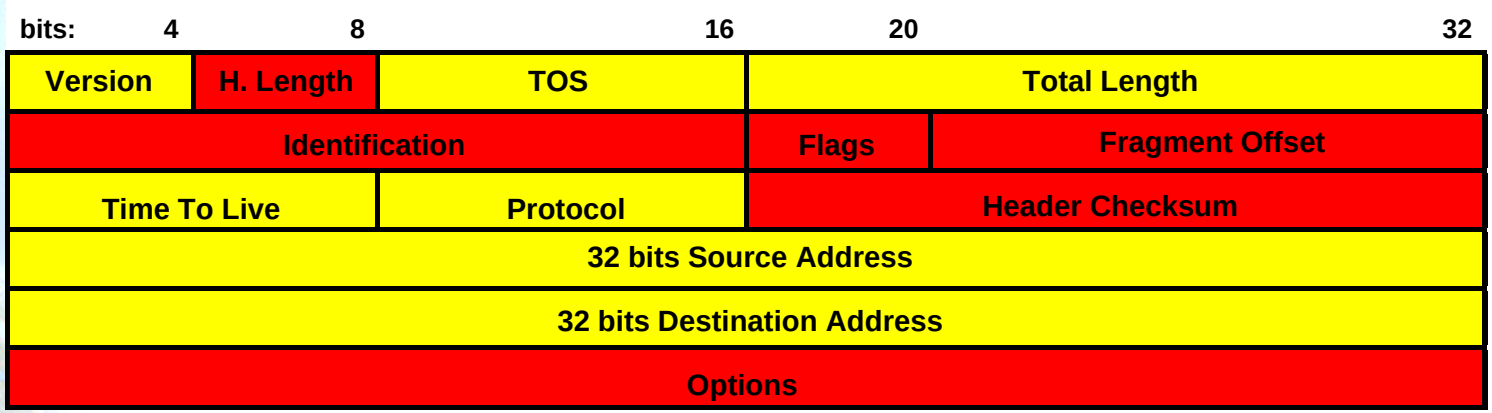
- PDU: Protocol Data Unit



- Layer 3 Header includes Source and destination Network Address (IP Address)
- Layer 3 y the only one common layer in Internet: IP

IPv4 Header Format

- 20 Bytes + Options (40 Bytes maximum)
  - Variable size: 20 Bytes to 60 Bytes

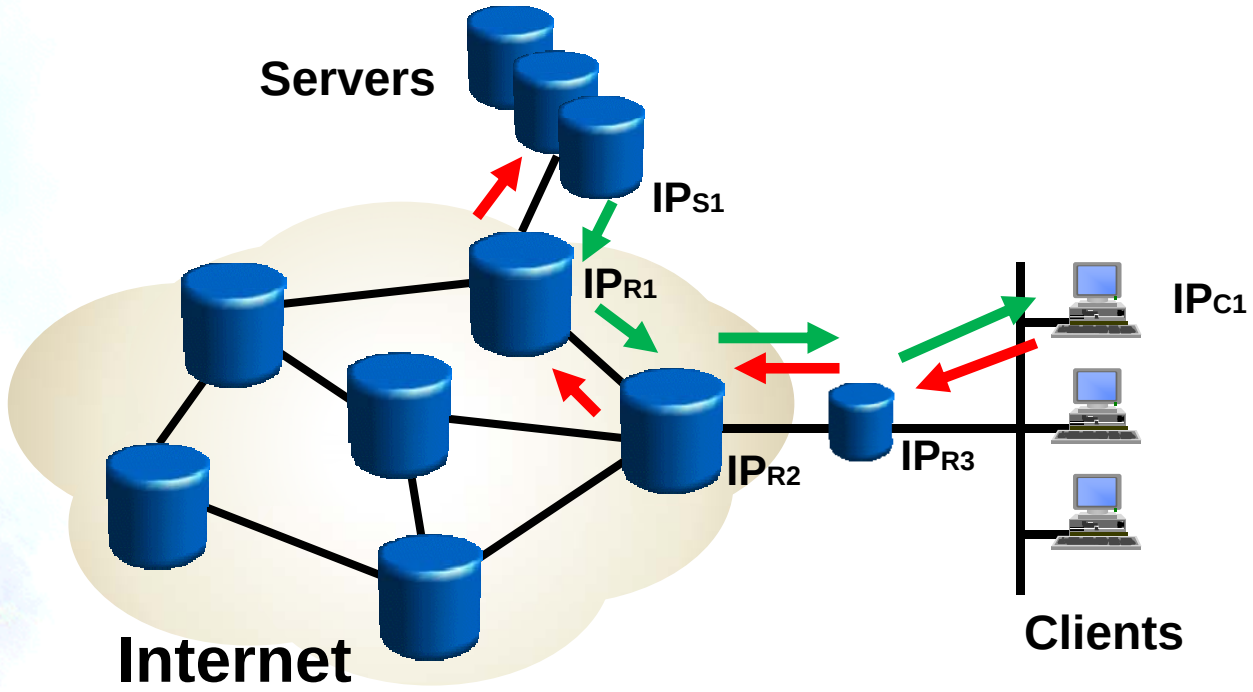


Networking Basics (5)

- Client-Server Applications: exchange L5 messages
- C1 need to know IP_{S1} and sends a packet to that IP (DNS)

dst IP_{S1}	src IP_{C1}	DATA

Layer 3 PDU (still the same all way long to server)



Networking Basics (7)

- In summary we have the **network layer** as the only layer that is present on all networking devices
- IP (Internet Protocol) is the de facto network layer protocol -> used in Internet
- Al devices in an IP network must have a unique IP address

3. Packet Forwarding

Packet Forwarding (1)

- We have seen that the Internet is based on the IP protocol
- Packet forwarding is done by routers: receive packets in one interface and have to decide to which interface to forward the packet
- Decision is taken based on:
  - Destination IP address
  - Routing table

Packet Forwarding (2)

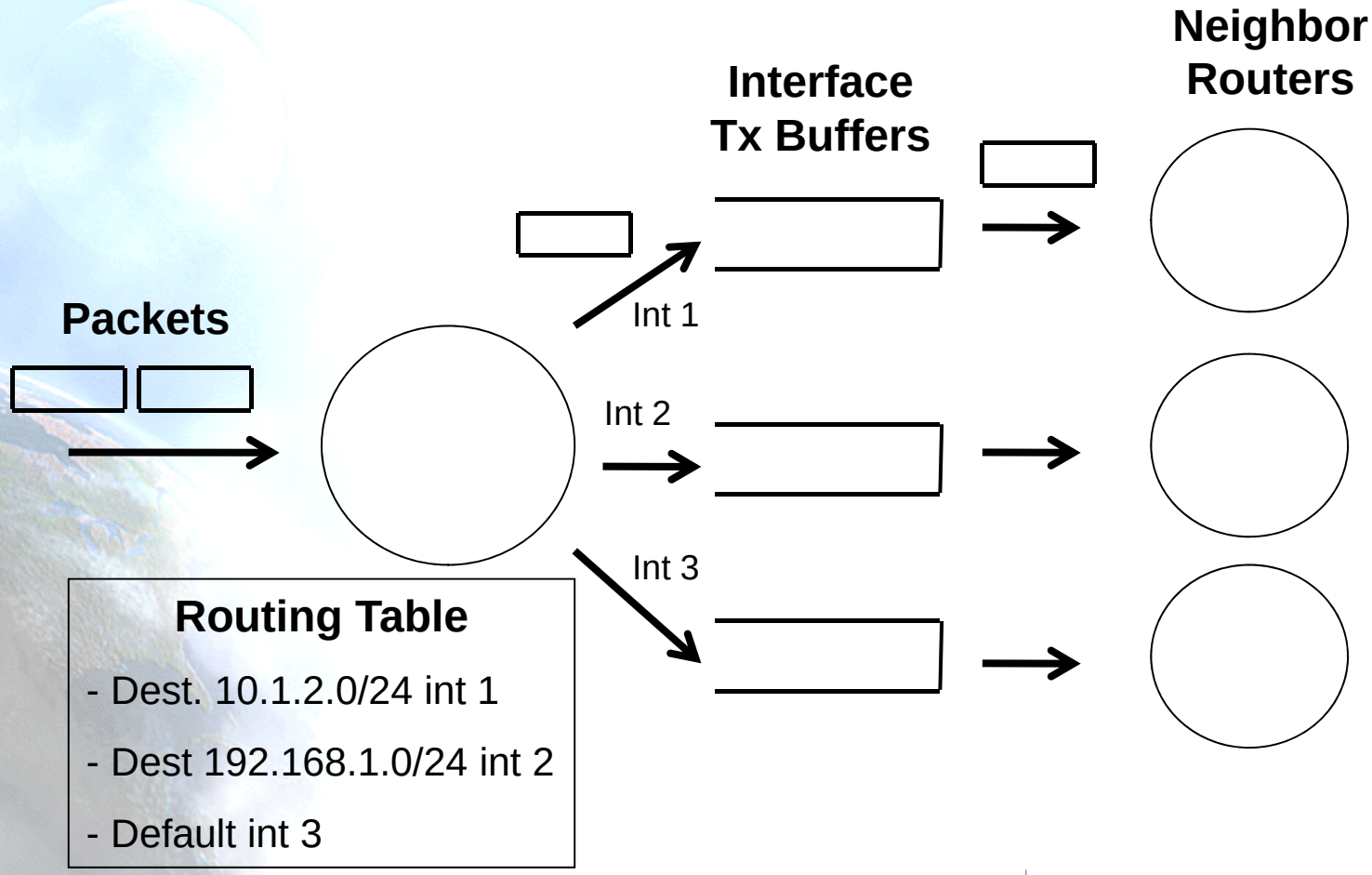
- The process:
  1. Create a routing table (will see routing protocols)
  2. Receive a packet in an interface
  3. Destination IP address in routing table? if so, packet assigned to an outgoing interface queue -> Tx
  4. If not, is there a default route? If so, packet assigned to default route interface queue -> Tx
  5. If not, the packet is discarded

Best effort behavior -> packets could be lost

Solution -> QoS (Quality of Service) -> priorities

Packet Forwarding (3)

- In summary we



4. Routing Protocols

Routing Protocols (1)

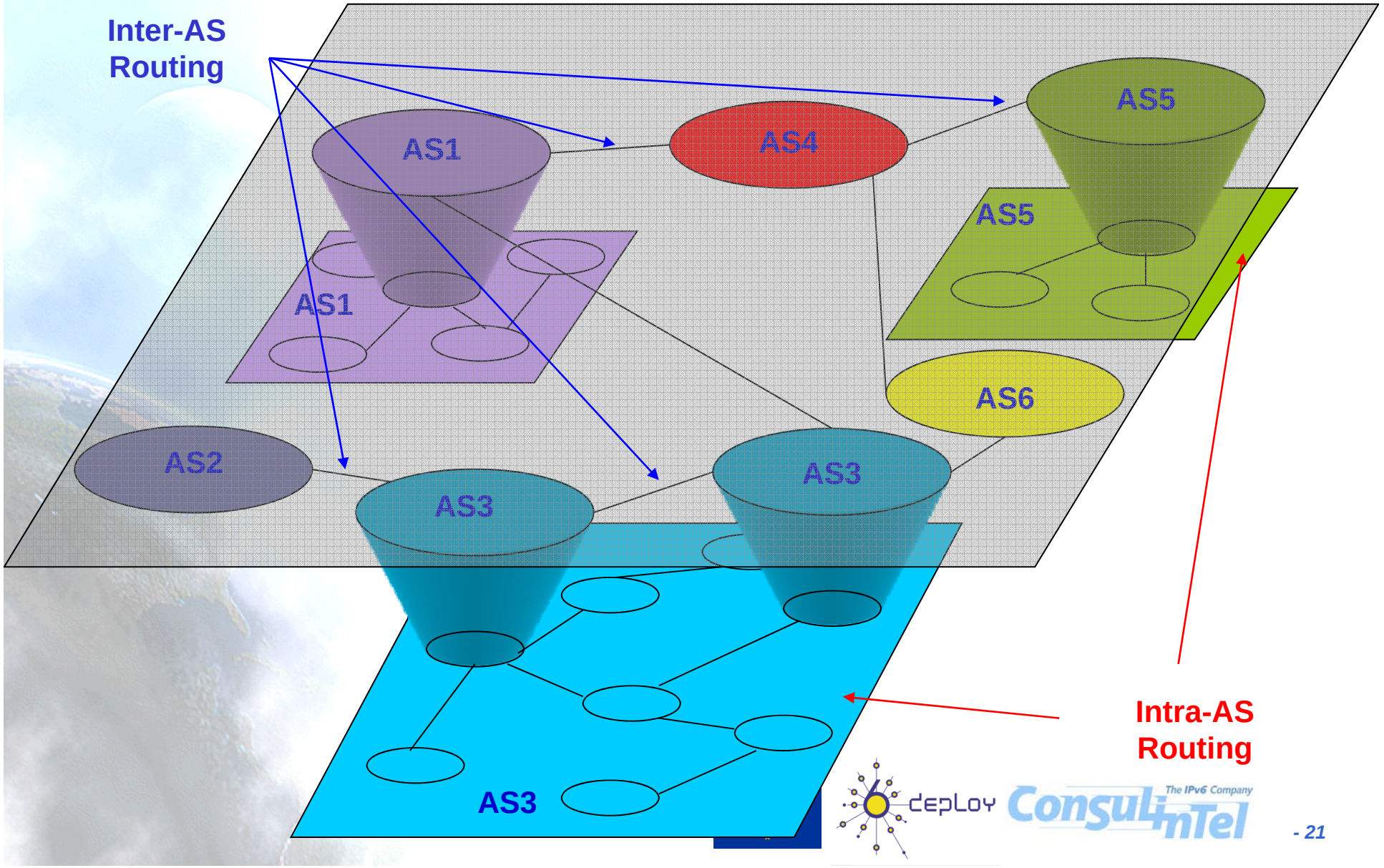
- Packet forwarding is based in the routing table
- Routing table guides the router decision
- Two ways of creating and maintaining the routing table:
  - **Statically**: manually entered routes, do not change unless administrator manually make changes, do not scale, do not adapt to network changes, easy to configure and manage (small net)
  - **Dynamically**: uses a routing protocol to create the routes, scale well, adapt to network changes, more complicated to manage and configure

Routing Protocols (2)

- Regarding the Scope:
  - IGP Interior Gateway Protocol (RIP. OSPF, IS-IS)
  - EGP Exterior Gateway Protocol (BGP)

- Types of IGPs
  - Regarding propagation
    - Distance-vector routing (examples: RIP, IGRP)
    - Link-state routing (examples: OSPF, IS-IS)
  - Regarding routes
    - Classful
    - Classless

Routing Protocols (3)



5. IPv4 Addressing

IPv4 Addressing (1)

- IPv4 addresses have 32 bits
- Represented using decimal notation of each byte (8 bits) separated by .
- Examples: 10.1.1.2, 192.168.11.1
- Each decimal number corresponds to 8 bits, for example: 10 -> 00001010
- Do you remember binary to decimal conversions?

IPv4 Addressing (2)

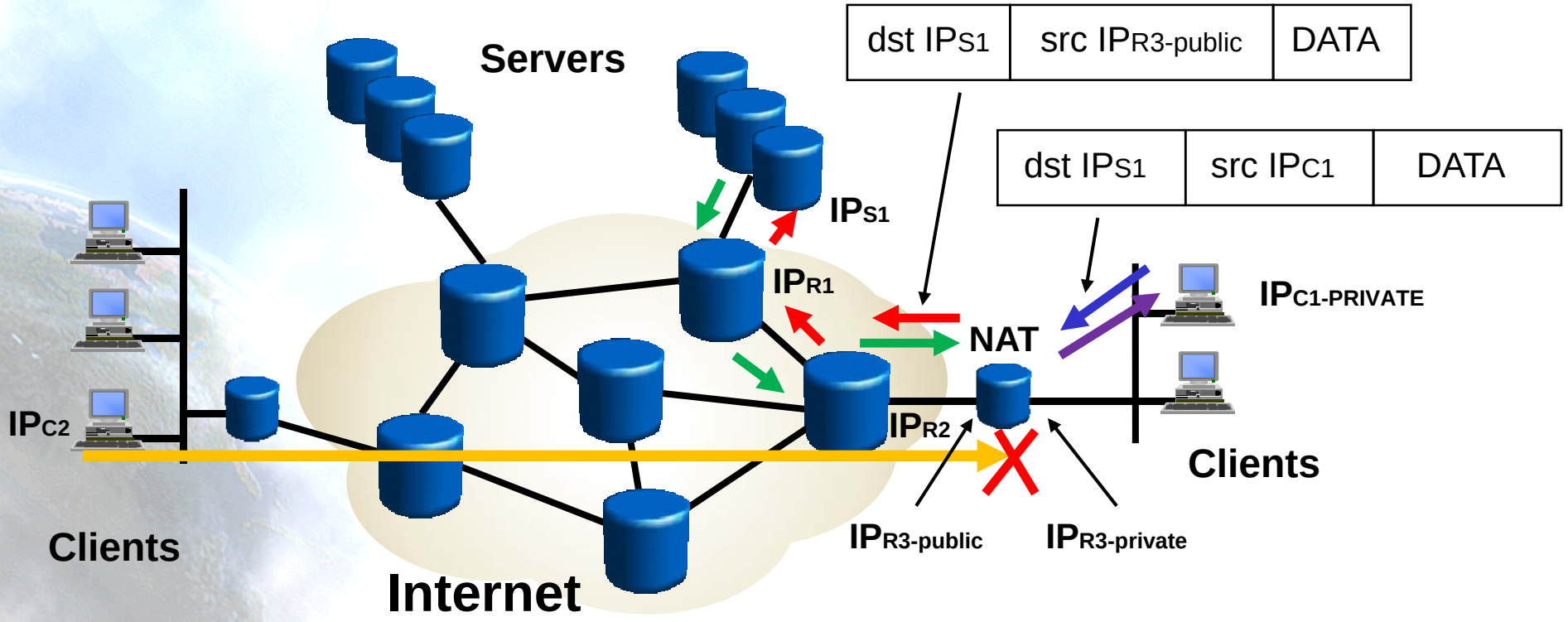
- At the beginning different “classes” were defined:
  - Class A: 8 bits mask (/8) -> first byte 0 to 127
  - Class B: (/16) -> first byte 128 to 191
  - Class C: (/24) -> first byte 192 to 223
- Later, classes were abandoned by CIDR (Classless Inter Domain Routing) Notation: prefix / length
- Example 10.1.2.0/24:
  - 24 bits network prefix
  - 8 bits for hosts
  - 254 possible host addresses (all 0s (network) and all 1s (broadcast) could not be used)

IPv4 Addressing (3)

- Private addresses were defined:
  - 10.0.0.0/8 (1 x A): 10.0.0.0 to 10.255.255.255
  - 172.16.0.0/12 (16 x B): 172.16.0.0 to 172.31.255.255
  - 192.168.0.0/16 (256 x C): 192.168.0.0 to 192.168.255.255
- Private addresses are used behind a NAT device
  - Works “well” in a client-server model
  - Do not allow for P2P or similar applications
  - Do not allow innovation on the Internet
  - Makes software development more expensive
  - Management and security gets harder

NAT

- NAT breaks end-to-end paradigm of Internet
- C1 need to know IP_{S1} and sends a packet to that IP
- But IP packet header is changed in the NAT device
- Private IP addresses are not reachable from outside



6. IPv4 Internet History

(Brief) Internet History (1)

- What we know as Internet started on 1963 as ARPAnet, a USA DoD project -> objective: fault tolerant data network
- In 1983 ARPANET changes its architecture to use TCP/IP -> linear growth
- In 1989 appears the WWW (World Wide Web) based on DNS, URL, HTTP and HTML -> 90's Internet grows exponentially
- Bad address assignment and Internet growth made the scarcity of addresses a foreseen problem
- CIDR, NAT and private addresses appeared as a solution -> changes the Internet architecture

(Brief) Internet History (2)

- After that the number of users, devices and applications making use of Internet growth exponentially
- The traffic also has grown exponentially because of the use of multimedia data (voice and video) and new uses like social networks

- Today we are facing a new change on the Internet: the exhaustion of IPv4 addresses and the (late) implementation of IPv6 -> For sure things are going to change!

Thanks !! Questions??

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The IPv6 Portal: http://www.ipv6tf.org