Tietoliikenteen infrastruktuurin kehityksestä

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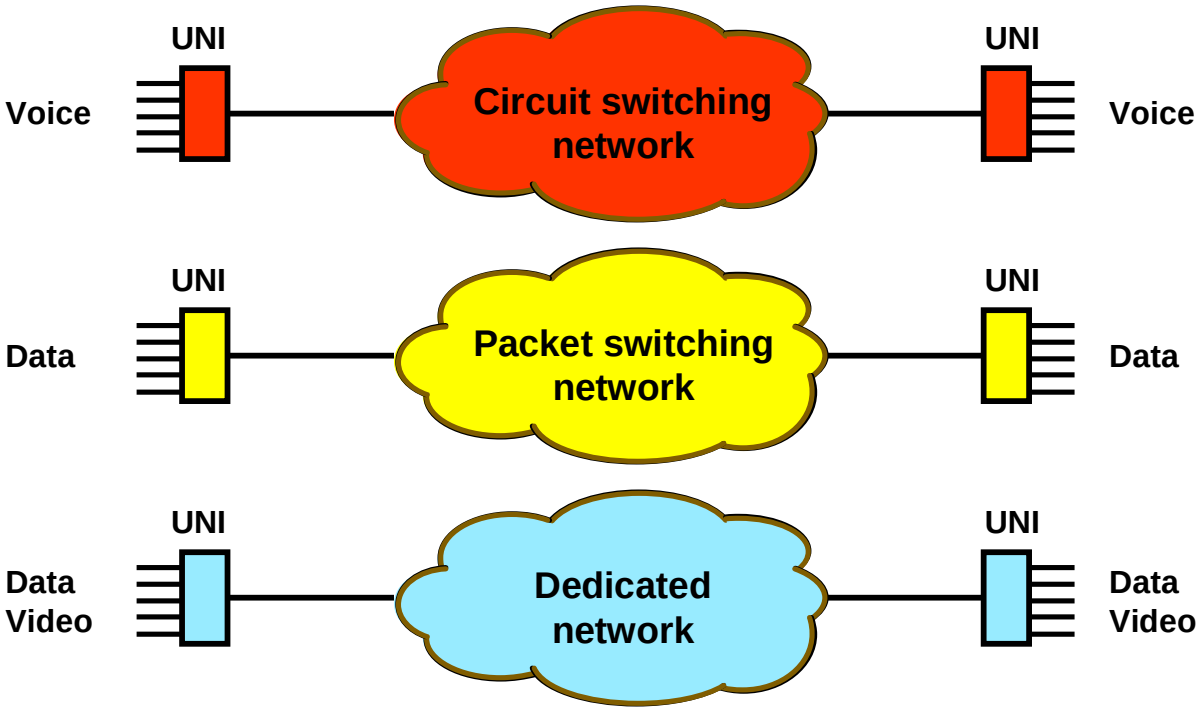
Outline

- From dedicated networks to All-IP networks
  - Development/evolution of transport network
- From circuits to packets
- Convergence vs. divergence
  - IP based network/service convergence
  - Access network divergence
  - Interworking to provide compatibility
- Aspects in IP networking
  - Basic architecture
  - Necessary functions: routing, control, DNS/ENUM
  - Some known problems

Segregated transport

- Early telephone systems used analog technology - frequency division multiplexing (FDM) and space division switching (SDS)
- When digital technology evolved time division multiplexing (TDM) and time division switching (TDS) became possible
- Development of electronic components enabled integration of TDM and TDS => Integrated Digital Network (IDN)
- Different and segregated communications networks were developed
  - circuit switching for voice-only services
  - packet switching for (low-speed) data services
  - dedicated networks, e.g. for video and specialized data services

Segregated transport

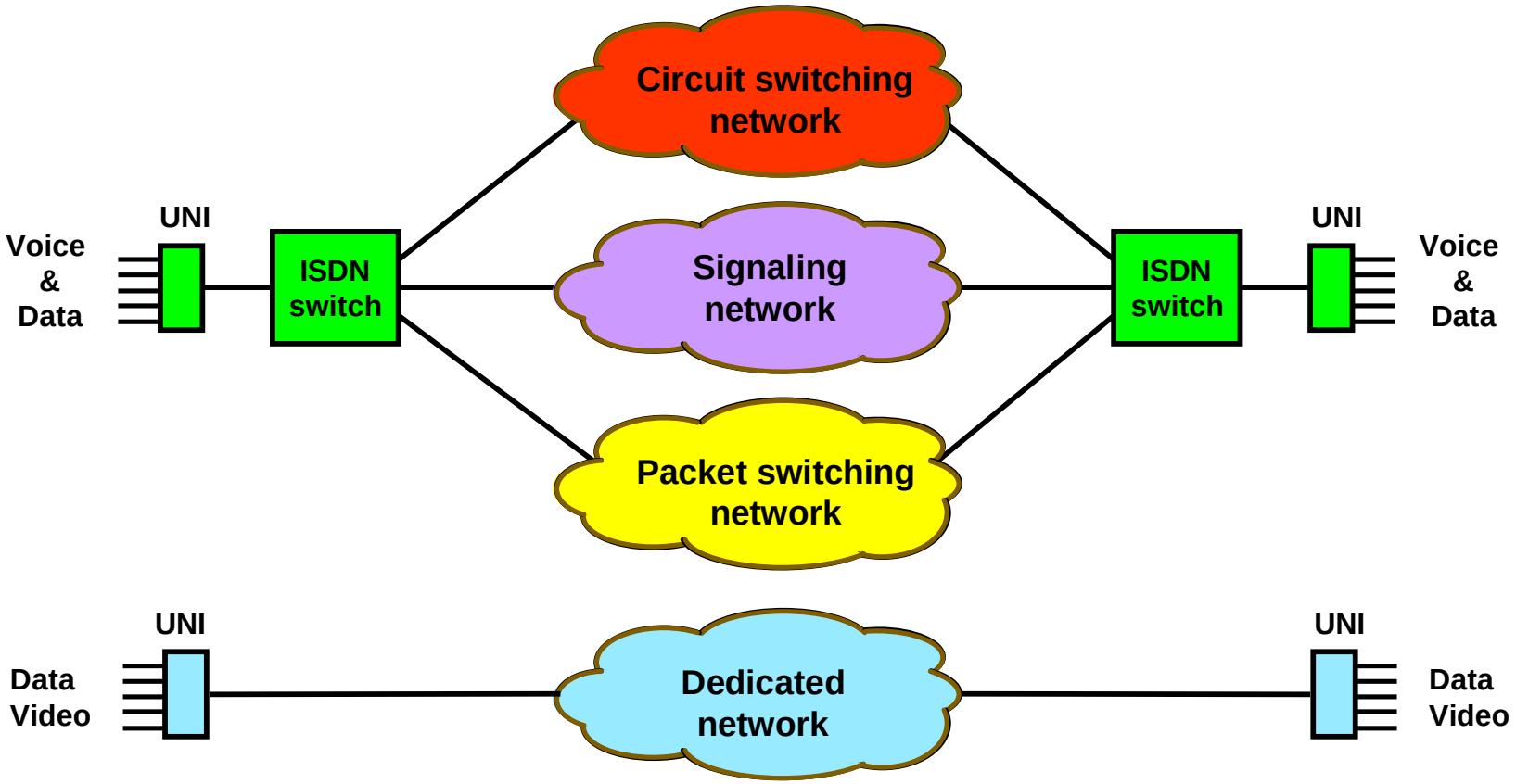


UNI – User Network Interface

Integrated transport

- Service integration became apparent to better utilize communications resources => IDN developed to ISDN (Integrated Services Digital Network)
- ISDN offered
  - a unique user-network interface to support basic set of narrowband services
  - integrated transport and full digital access
  - inter-node signaling (based on packet switching)
  - packet and circuit switched end-to-end digital connections
  - three types of channels (B=64 kbit/s, D=16 kbit/s and H=nx64 kbit/s)
- Three types of long-distance interconnections
  - circuit switched, packet switched and signaling connections
- Specialized services (such as video) continued to be supported by separate dedicated networks

Integrated transport

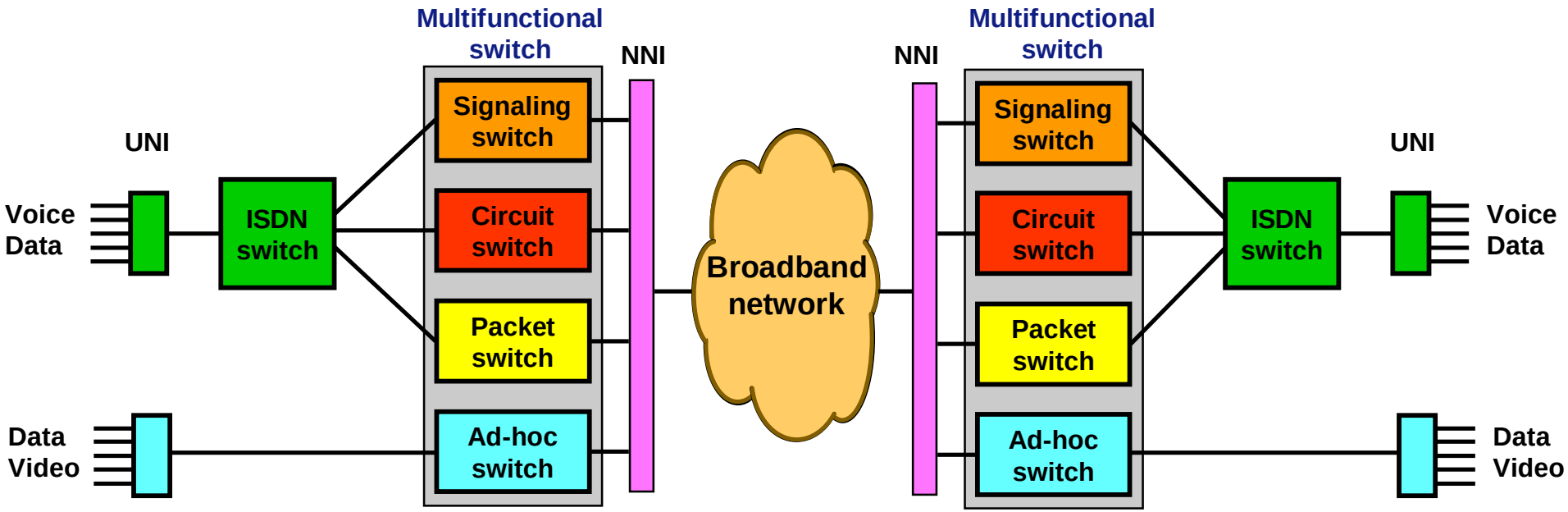


UNI – User Network Interface

Narrowband-integrated access and broadband-integrated transmission

- Progress in optical technologies enabled huge transport capacities
  => integration of transmission of all the different networks (NB and BB) became possible
- Switching nodes of different networks co-located to configure multifunctional switches
  - each type of traffic handled by its own switching module
- Multifunctional switches interconnected by broadband integrated transmission (BIT) systems terminated onto network-node interfaces (NNI)
- BIT accomplished with partially integrated access and segregated switching

Narrowband-integrated access and broadband-integrated transmission

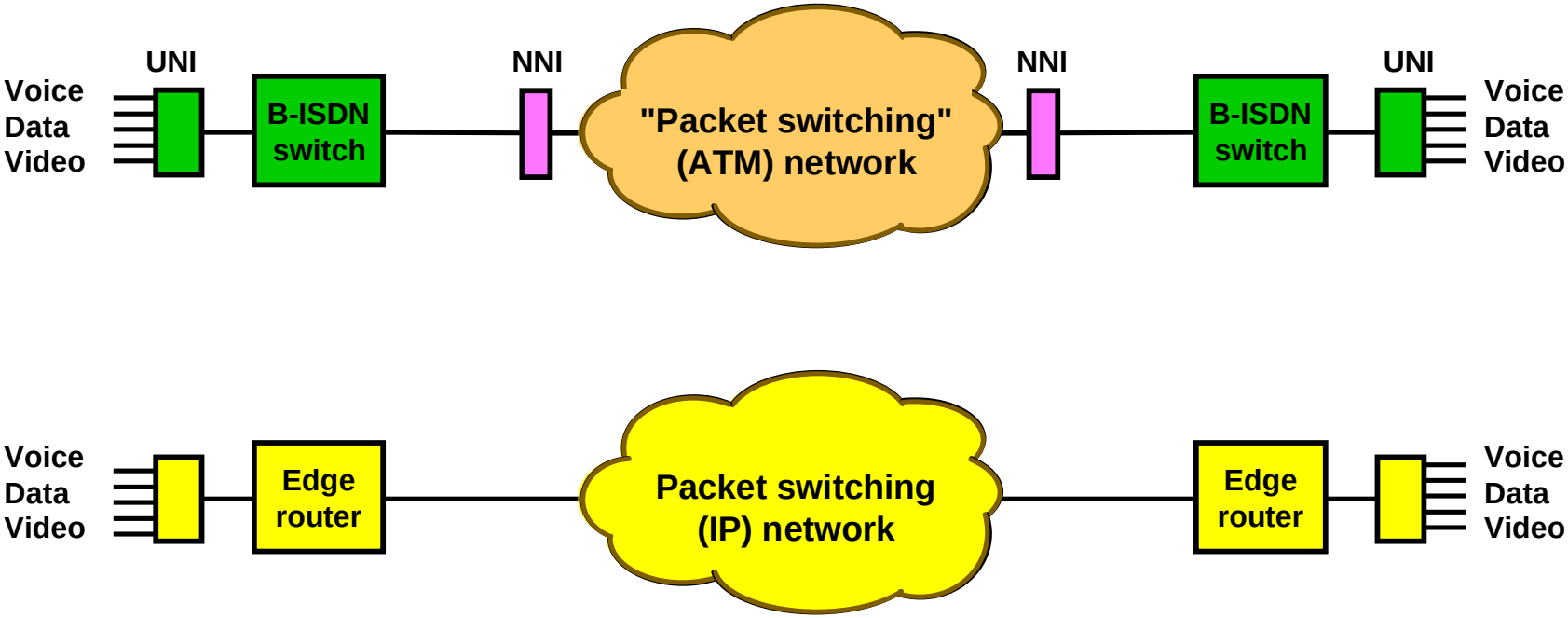


UNI – User Network Interface
NNI – Network-to-Network Interface

Broadband integrated transport

- N-ISDN had some limitations:
  - low bit rate channels
  - no support for variable bit rates
  - no support for large bandwidth services
- Connection oriented packet switching scheme, i.e., ATM (Asynchronous Transfer Mode), was developed to overcome limitations of N-ISDN
  => B-ISDN concept
  => integrated broadband transport and switching (no more need for specialized switching modules or dedicated networks)

Broadband integrated transport



UNI – User Network Interface
NNI – Network-to-Network Interface

From circuits to packets

q **Circuit switching**

- Connections established prior to transfer of information and released when transfer is finished
  => start-up delay
  => inefficient use of transport capacity
- Capacity reserved only for the established connection
  => high QoS guaranteed (low delay, limited delay variance, assured bit rate)
  => waste of capacity
- Signaling and maintenance information carried in dedicated channels
  => user traffic cannot disturb signaling
  => difficult to intrude intentionally into network control system
- Transport network closed and managed only by its operator
- Well standardized

From circuits to packets (cont.)

q **Packet switching**

- No connection establishment nor release phase
  => no start-up delay
  => transport capacity immediately in use
- Statistical multiplexing ensures high utilization of transport capacity
  => a large number of connections/users share the same transport resource
  => transport channels can get congested
  => lowered QoS (low delay, limited delay variance, assured bit rate)
- No dedicated channels to carry signaling and maintenance information
  => user traffic can disturb signaling
  => possible to intrude into the network control system
- Openness
  => loosely standardized
  => network (and national) boundaries disappear
  => unpleasant side-effects, e.g. spam, host hijacking and DDoS attacks

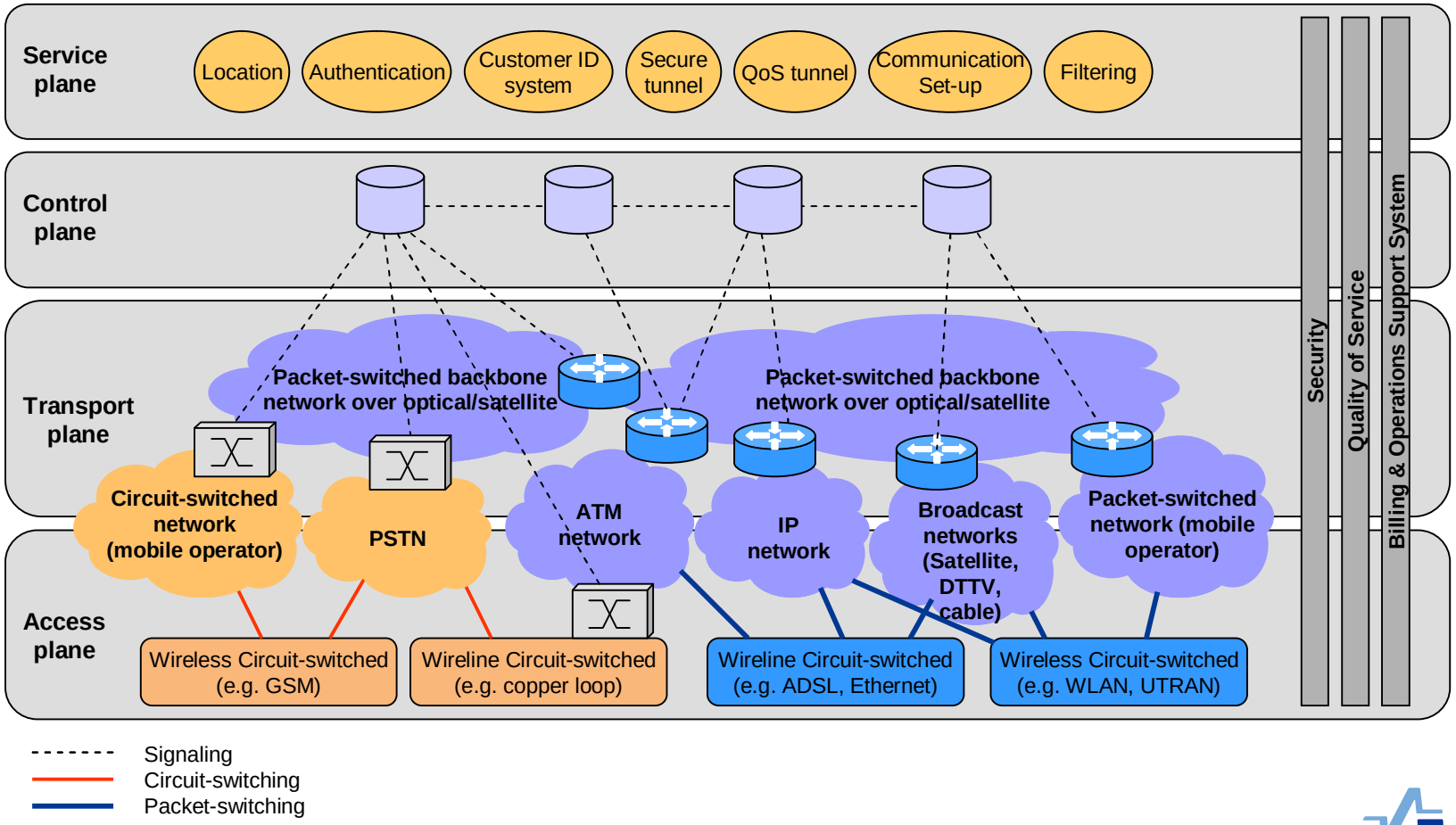
Convergence vs. divergence

- **Convergence**:
  - Applications over Internet Protocol, icl. conventional telecom services
    => quality and interworking problems
    => redevelopment of telecom services for IP transport
    => more control protocol
- **Divergence**
  - New transport techniques evolve
    - Next gen. SDH, carried grade Ethernet, OTN
  - Competing access techniques evolve
    - xDSLs, cable modems, GPRS, HSDPA, WLAN, WiMax, 4G, etc.

  => gross-layer design and new signaling methods to negotiate end-to-end network recourses for connections

  => enhanced handover/roaming solutions to carry IP packets seamlessly over diverse networks

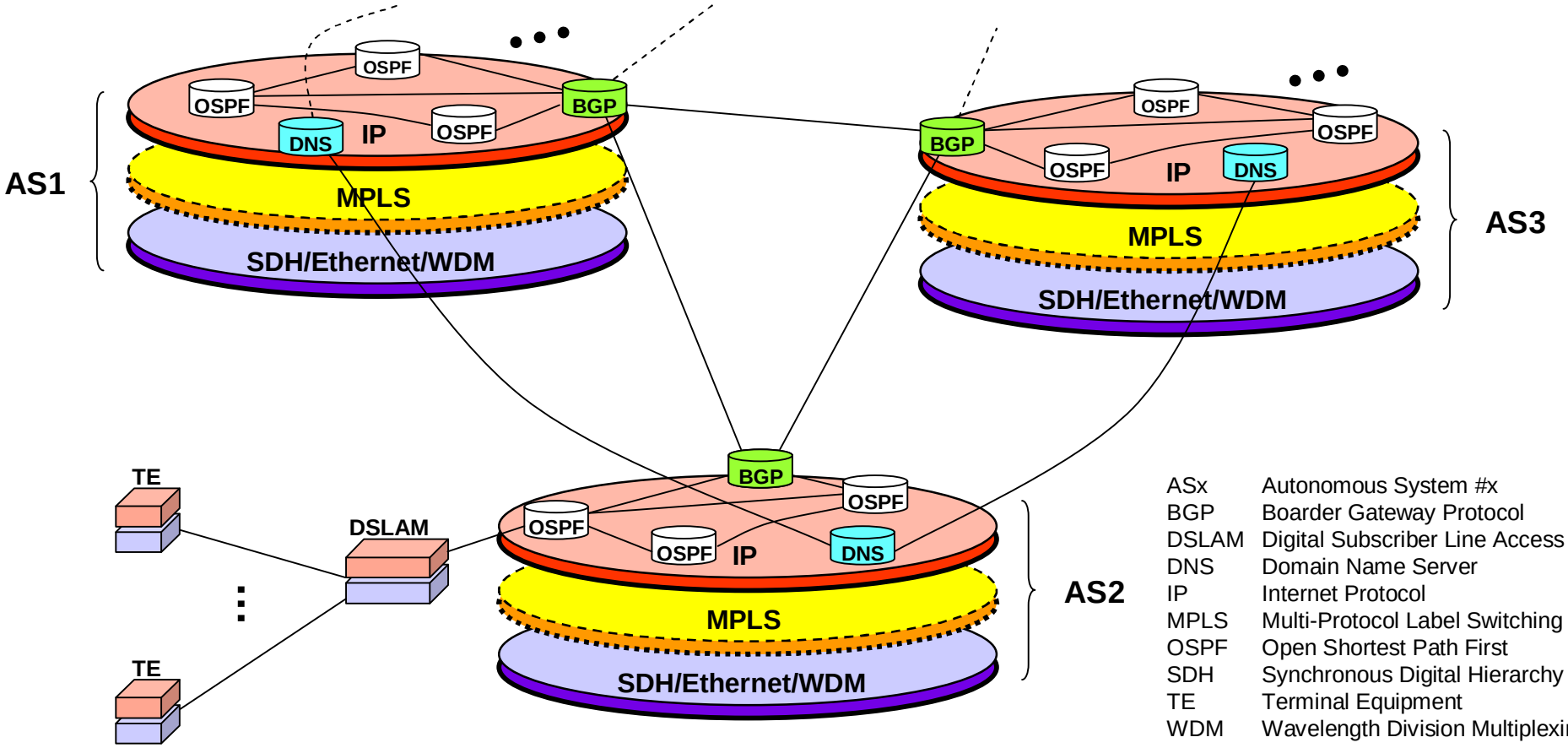
Architectures model (ITU-T NGN)



Aspects in IP networking

- **Layered architecture**
- Packet switched
- Basic functionality
  - Routing: inter AS (e.g. BGP) and intra AS (e.g. OSPF and IS-IS)
  - Separate control protocols, e.g., ICMP and IGMP
  - Switching to speed up routing (MPLS)
  - Domain name service (DNS/ENUM), NAT
- Known problems

Internet architecture



ASx	Autonomous System #x
BGP	Boarder Gateway Protocol
DSLAM	Digital Subscriber Line Access Multiplexer
DNS	Domain Name Server
IP	Internet Protocol
MPLS	Multi-Protocol Label Switching
OSPF	Open Shortest Path First
SDH	Synchronous Digital Hierarchy
TE	Terminal Equipment
WDM	Wavelength Division Multiplexing

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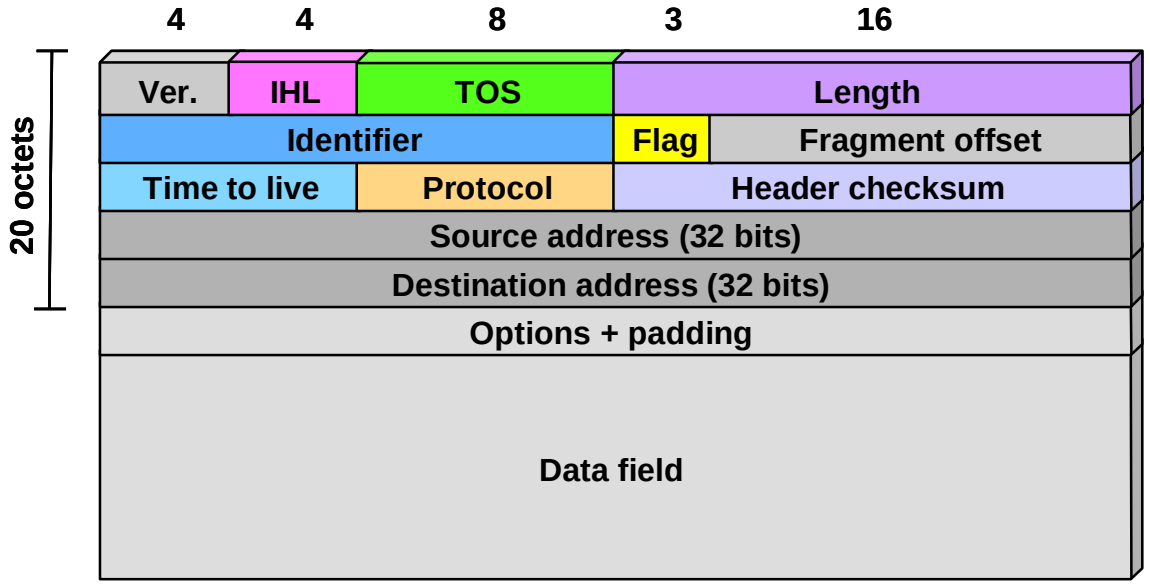
IPv4 packet format



Aspects in IP networking

- Layered architecture
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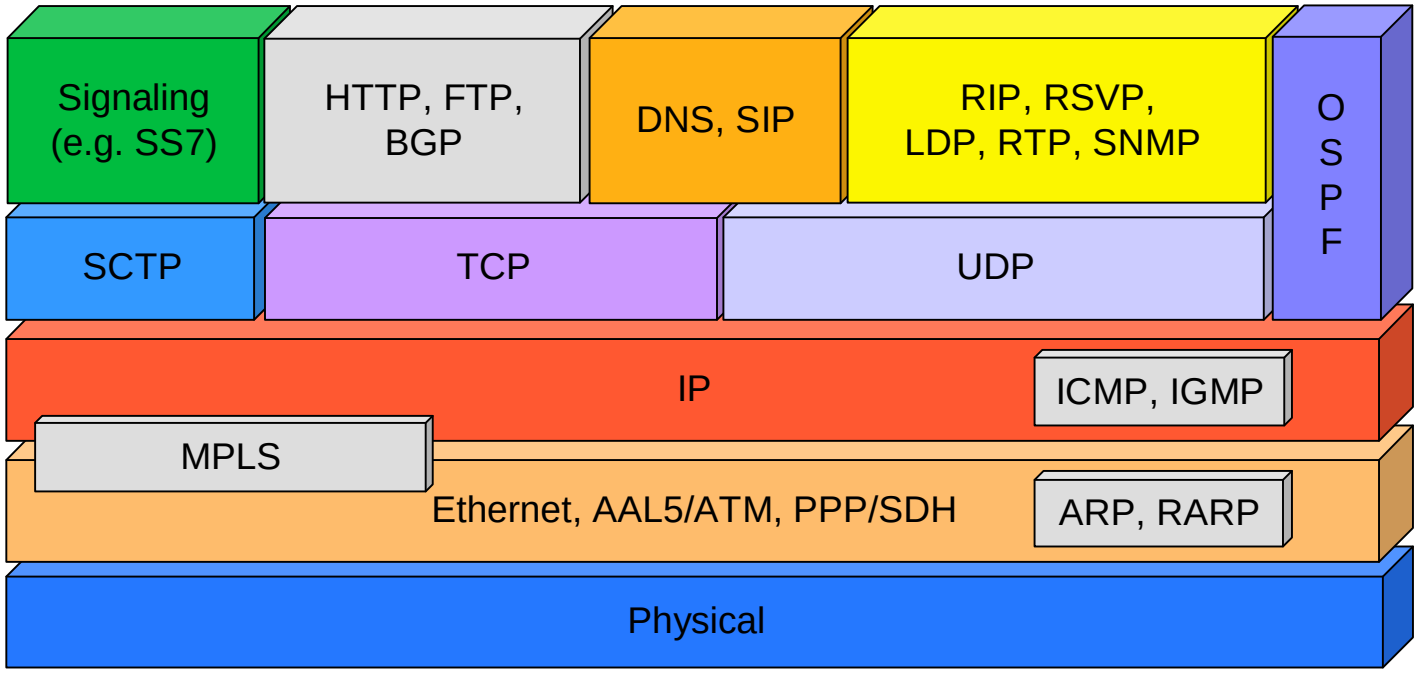
Example Internet protocol stack



Some known problems in IP networks

- No guarantee for packet delivery
- Congestions possible
  => delay and delay variation increases
  => packet loss rate increases
  => network resources seen by a service decline
- Misconfiguration of routers
  - Routing protocols may cause route oscillation
  - Loss of routing information
  - False routing of packets

Some known problems in IP networks (cont.)

- **Spoofing**
  - A technique used to gain unauthorized access to computers
  - man-in-the-middle - packet sniffs on link between the two end points, and can therefore pretend to be one end of the connection
  - routing redirect - redirects routing information from the original host to the hacker's host (this is another form of man-in-the-middle attack)
  - source routing - redirects individual packets by hackers host
  - blind spoofing - predicts responses from a host, allowing commands to be sent, but can't get immediate feedback
  - flooding - SYN flood fills up receive queue from random source addresses (smurf/fraggle spoofs victims address, causing everyone respond to the victim)

Some known problems in IP networks

- **DNS problems**
  - DDoS – a lot of messages (e.g. ping) sent to disturb root servers
    => anycast addresses to over the problem
  - DNS pollution – data traffic that should not exist
    - *A-for-A* (DNS client asks for an already known address)
    - *RFC 1918 leak* (addresses reused throughout in the private internets
    - *identical and repeated queries* (queries for names that have already been queried
    - *referral-not-cashed* (e.g. client sends a query to a *abc.org* while it already has queried *cde.org*)
    - *invalid TLD* (query for a name not matching an existing Top Level Domain)

=> False configurations together with insufficient understanding of IP networks cause the major portion of the performance problems