Réseaux émergents / Emerging networks

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Course organization, learning skills and grading

- **UF : Communication**
- **4 lessons**
  - 3 Chapters :
    - *Chapter 1 : A brief overview of emerging networking paradigms*
    - *Chapter 2 : Software Defined Networking*
    - *Chapter 3 : LISP (unlikely to be covered this year)*
  - 2 lab sessions: SDN & network virtualization
  - Learning skills
    1. *assess the general benefits and main limitations of adopting SDN (and network softwarisation) in an IoT application*
    2. *Design, set-up and operate a basic/academic SDN based IoT Network*
  - Course grading :
    - *A quiz with unlimited number of retries to pass with a required grade mark of 100%*
    - *Paper reading + analysis*

Chapter 1 : A brief overview of emerging networking paradigms

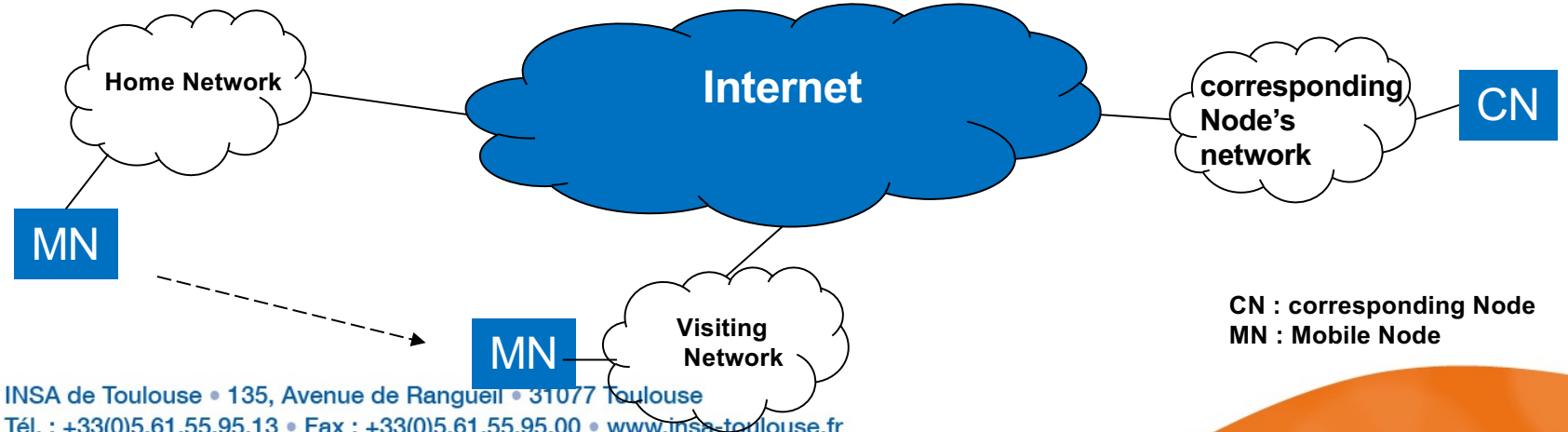
Main requirements on computer networks

- **Scalability**
- **Node Mobility & multi-homing**
- **Support variety of services (with different QoS requirements)**
- **reduced energy consumption**
- **End device Heterogeneity**
- **Security**
- **Network flexibility**
- **Simplified Network management**
- **…**
- **Intuitively, is the Legacy Internet the answer ?**
  - No ! It suffers from its design assumptions and some of its design choices

Mobility & multihoming

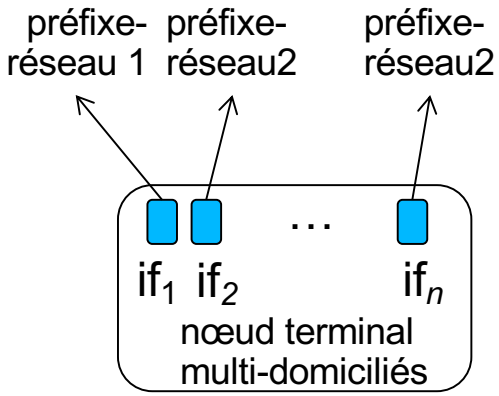
- **Implicit assumption at the creation of the Internet**
  - Nodes are not mobile
  - End nodes have a single interface
- **Internet's design choice : The IP address is used for two different purposes :**
  1. to locate an end-node and route the traffic to this location
  2. to identify the end node (the communication sessions)
- **What if an end-node is mobile ?**

IP Connectivity survivability ?
Application sessions survival?

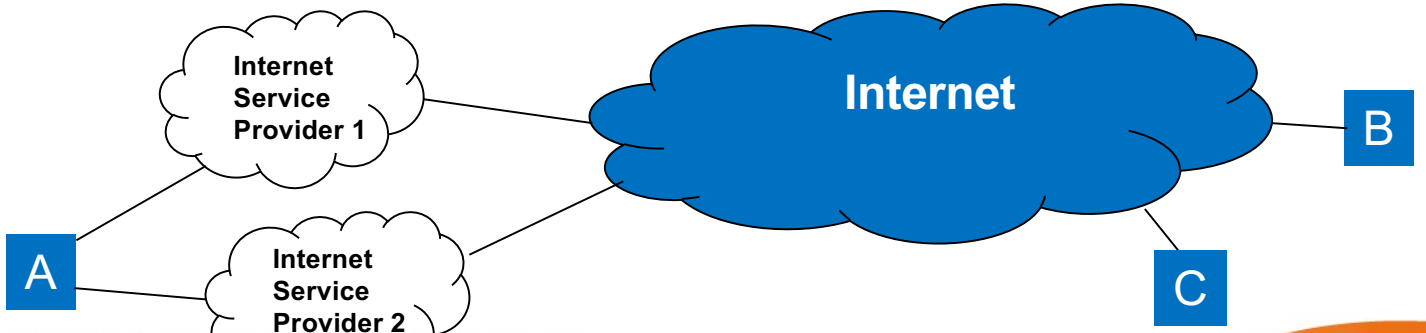


Mobility & multihoming

- **End-host multihoming**



- **Do we take advantage of the presence of multiple network interfaces ? What if the active interface fails ?**



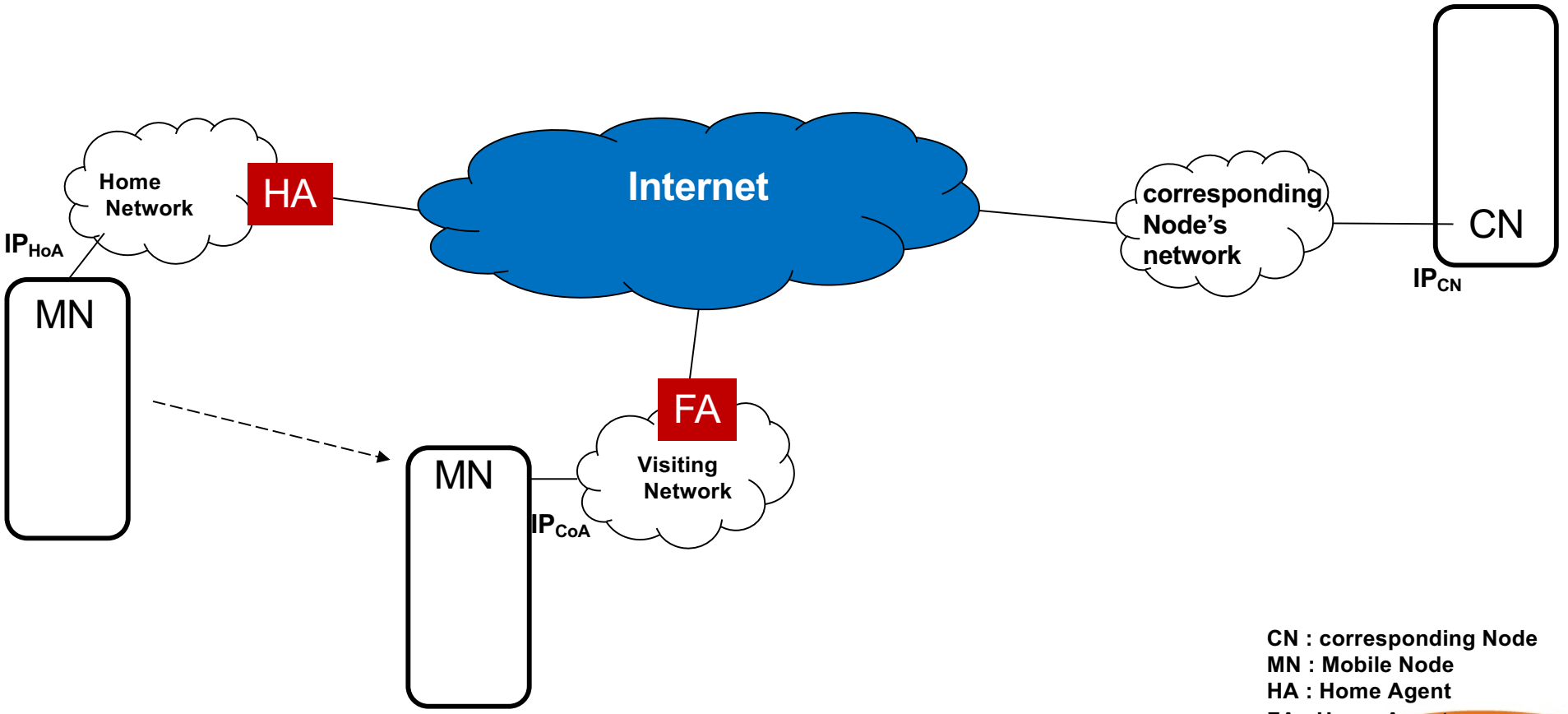
Mobility & multihoming

- **Mobility vs Multihoming ?**
  - Multihoming can be seen as a kind of mobility, usually called : vertical mobility
  - Share part of their objectives ?

  - Under quite different assumptions
    - *Network configuration ?*
    - *How to detect the need for a network configuration switch ?*
    - *network configuration changes occurrence ?*

Mobility

- **Many incremental solutions, amongst: Mobile IP and its variants**



CN : corresponding Node
MN : Mobile Node
HA : Home Agent
FA : Home Agent
HoA: Home Addrerss
CoA : Care of Address

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Multihoming

- **Many solutions :**
  - At the network layer with some form of Network address translation
  - At the transport layer by achieving session survival despite changes in network configuration

Location and ID separation

- **General idea:**
  - Use a unique node identifier regardless of its network attachments
    - *Often an @IP, but not necessarily*
  - @IP used for node location: can change over time
  - Address resolution required Identifier => @IP used for location
    - *At end hosts or intermediate nodes (typically, LISP protocol)*

- **How Mobility and multi-homing are supported ?**

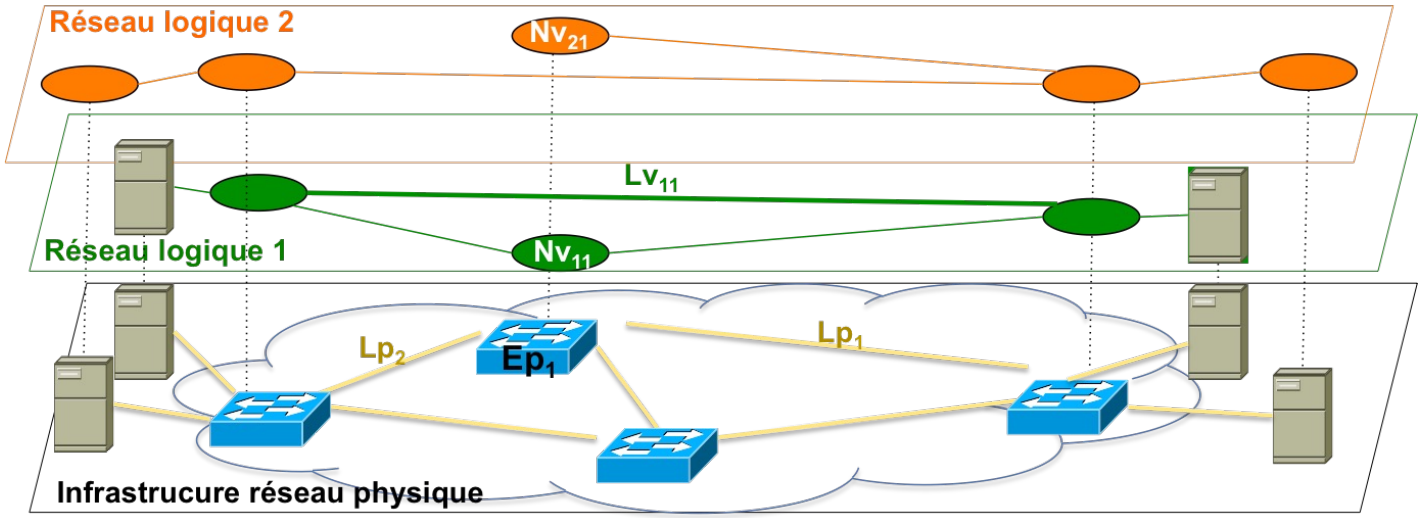
Provision of different network services

- **Internet service ?**
  - 1 single network service : best-effort
  - Hard to insert and deploy new services at the scale of the Internet

- **How to provide multiple network services : QoS, Multicast, … ?**
  - **Now** : Overlay networks
  - Network virtualization

Provision of different network services

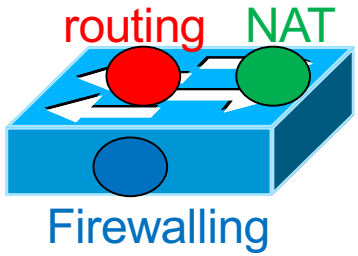
- **Network virtualization**
  - Node and link virtualization

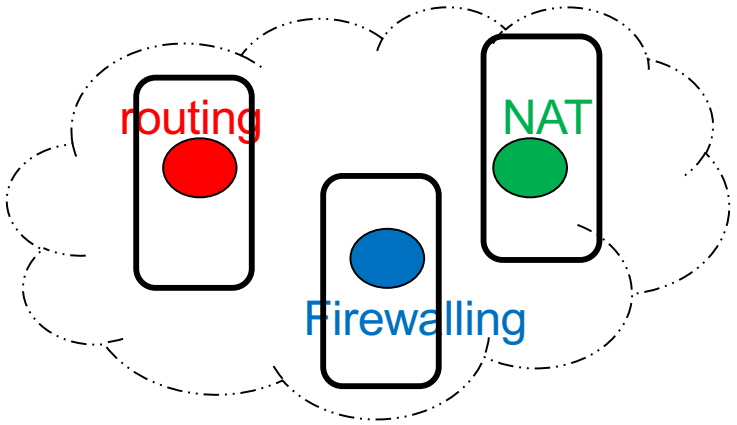


  - **Provided and tuned on demand**

NFV (Network Function Virtualization)

- **Implementing Network Functions as independent software modules running on virtual machines on standard servers instead of proprietary hardware/appliances**
  - Network Functions : Routing, firewall, NAT, DPI,IDS, DHCP, compression, etc.





- **Main benefits:**
  - Flexibility
    - *To change on the fly the network behavior*
    - *Adjust the required resources according to current needs*
  - Investment and operational costs
  - A network service can be seen as a chained VNFs that a packet flow must go through

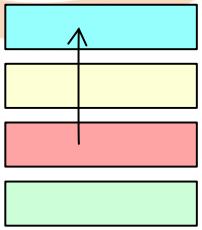
Cross-Layering

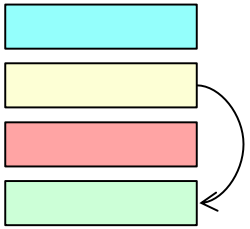
- **Design principles of Network Architectures**
  - organized and divided into layers
  - Each layer is built on top of the one below it
  - each layer should fulfill a limited and well-defined purposes by means of protocols
  - Each layer offers services to the respective higher layer and encapsulates the implementation specific details and provides an abstract interface for its service

- **Cross-layering ?**
  - Design methodology that violates the design principles of a reference architecture (TCP/IP, IEEE, etc.)

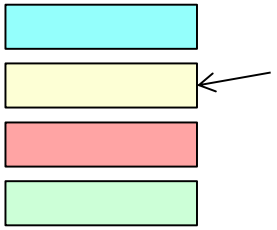
Cross-layering ?

Non stantard Interfaces exposing informations from lower layers

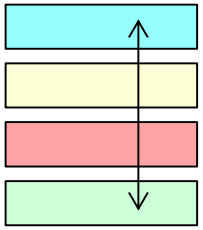




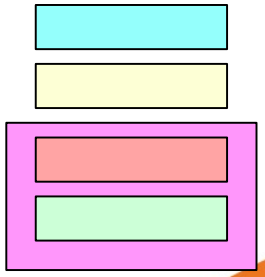
Interfaces to set lower layer protocol parameters



Protocol Design that exploits knowledge from lower layer protocols



Joint parameter configuration on multiple layers



Combine two layers

Cross-Layering

- **Rationale behind cross-layering ?**
  - Optimizing/enhancing the performance of communication networks (typically wireless)

- **Basic Examples :**
  - TCP Behavior when crossing a wireless network
    - *ECN : Explicit congestion Notification*
  - Routing in wireless networks
    - *Routing Metric*
    - *Neighbor discovery*

Delay/Disruption Tolerant Networking

- **Implicit assumption at the creation of the Internet**
  - End and intermediate nodes are always connected and end-to-end network connectivity, when ON (possible), is bidirectional
  - In a nominal scenario, end-to-end network connectivity is always provided with decent delays
- **In some applications : nodes connectivity is the exception, not the rule**
  - Examples ?
  - Conventional protocol stacks do not work, e.g. IP or TCP, ..
- **Network Architecture must be reworked : Delay Tolerant Networks**
  - *"store and forward" => "store, **carry** and forward"*
  - *Many proposals, depending on the application scenario*

Information Centric Networking (ICN)

- **Most of the traffic flowing through the Internet is related to a content : video, music, etc.**
- **The Internet follows a host-centric Networking paradigm**
  - From the content, one of the end-nodes hosting the content is identified, from which the content is requested
  - What if the same content is requested by users attached to the same network?

- **Main idea of ICN : content caching at the edge or inside the network (ICN routers) + routing and forwarding based on the identifier of the content**

Simplifying Network management

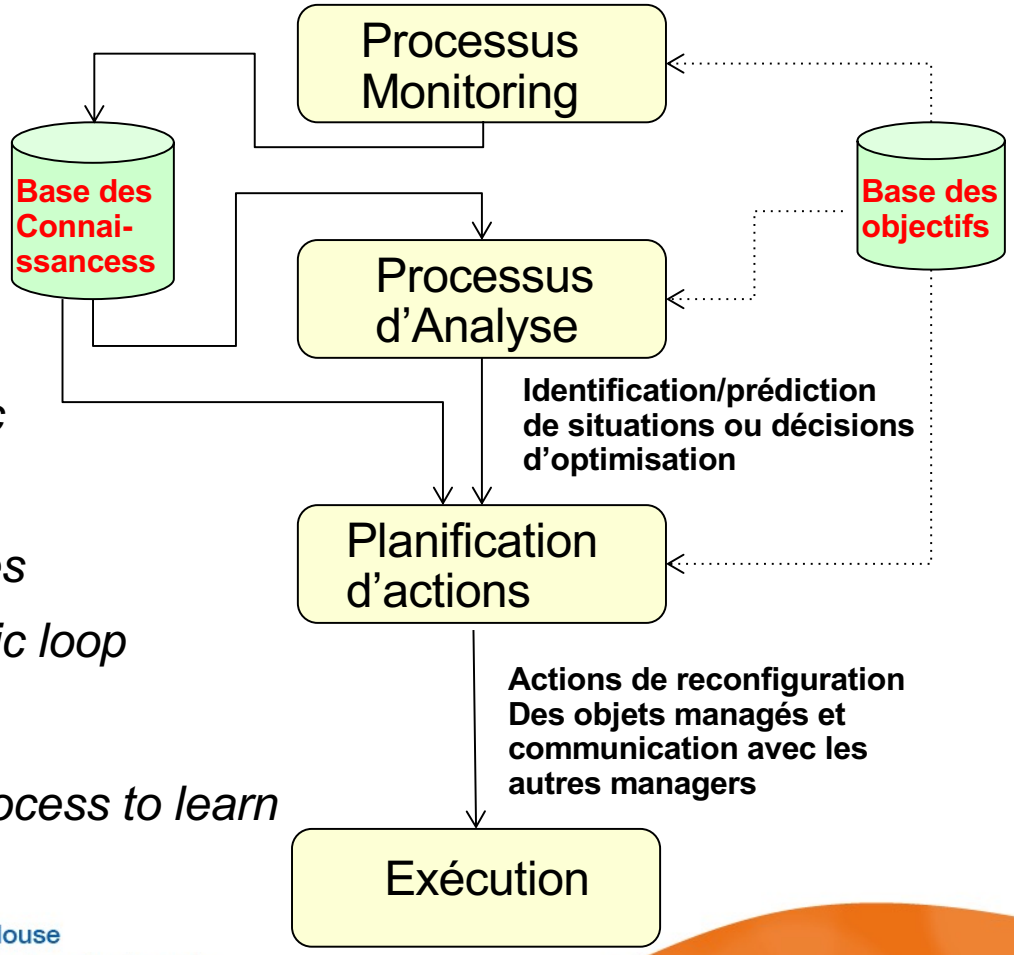
- **Network management is tedious work and error prone**
  - proliferation of network equipments, from different vendors, with different OS versions and capabilities

  =>> Networks are not sufficiently flexible to rapidly meet changing user demands

- **Some of the paradigm aiming at easing network management and improving flexibility**
  - SDN (Software Defined Networking)
    - *next chapter*

Simplifying Network management

- Autonomic Networking
  - *Networks embrace all management tasks, without human intervention, following high level objectives defined by network administrators*
  - *Self-management covers :*
    - Self-configuring,
    - self-healing,
    - self-optimizing et
    - self-protecting
  - *Classically composed of autonomic managers in charge of managed components (manages their resources and software) following the autonomic loop*
- Cognitive Networks
  - *Autonomic networks + cognitive process to learn From their experience*



Nouveaux paradigmes /concepts/directions

- Séparation des fonctions de localisation et identification
- SDN, Réseau autonomique, réseaux cognitifs
- Virtualisation réseau
- Network Function Virtualization (NFV)
- Cross-layering
- Delay Tolerant networks
- Information Centric Network