Chapter 2 - Network Architecture Evolution

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Section 1- New networking paradigms
- 1- IPv6 and Home Networking
- 2- “Beyond IP” architecture of the future Internet
- 3- Research Challenges in Wireless Sensor Network Architectures

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1- IPv6 and Home Networking

- **IP basic**
  - Maintain uniqueness for addresses allocation
  - IPv4: hierarchical address, private addresses (NAT)
  - NAT: equipments behind a NAT cannot be joined directly and they do not know their public addresses
  - IPv6 has been designed to transport information as fast as possible from one point in the network to another. (always-on, machine to machine communications,...)
  - IPv4→IPv6: a difference between a packet format and an addressing scheme
    - Core Network, Access Network, Home network
    - In IPv4, providers manage addresses; in IPv6 they will manage prefixes.
1- IPv6 and Home Networking

- **Core network**
  - forwarding and routing packets
  - Some techniques based on MPLS, L2 VPN and in some case tunneling, may help to handle efficiently IPv6 packets.

- **Access Network**
  - Internet Access Provider, which adds to the core network
  - IPv6 prefix delegation and authentication
  - Softwires (IETF working group)
    - Softwires connectivity will disappear when all the provider networks have been updated to manage natively IPv6.
Home Network

Currently Home Networks are very simple and are composed of a single link where Ethernet and Wi-Fi are bridged.

The network topology may be complex due to the different technologies used to transport information.

IPv6 will provide full connectivity and end-to-end applications.

New protocols will have to be designed to handle networks and applications auto-configuration. This will allow hiding IP to the application and will have also an impact on embedded systems and machine to machine communication.
2- “Beyond IP” architecture of the future Internet

- A new Internet architecture must deal with a multi-ordered requirements set
  - with many requirements taking on different importance at different times, and in different regions of the network
  - Mobility, Policy-driven Auto-Configuration, Highly time-variable resources, Allocation of Capacity, Extremely long propagation delays
2- “Beyond IP” architecture of the future Internet

- Study of new Internet architecture
  - Co-existence of IPv4 and IPv6 during transition period and techniques including address and header translations, tunneling and interoperation between IPv4 and IPv6 domains
  - Quality of Service (QoS) related to traffic management and traffic engineering, Service level agreements (SLA)
  - Multi-Protocol Label Switching (MPLS) – flow label marking
  - Automatic configuration
  - (1) scaling issues, (2) heterogeneity, (3) high performance, and (4) interaction with economic and business models
3- Research Challenges in Wireless Sensor Network Architectures

- **Usage of WSN**
  - Disaster relief, homeland security, precision agriculture, fire control, vehicle guidance and intelligent building

- **Consideration of**
  - the type of service provided and its quality, the tolerance to faults, the network lifetime and scalability, the programmability of the nodes and the maintainability of the network
3- Research Challenges in Wireless Sensor Network Architectures

- WSN architecture research
  - Distributed organization of the network
  - The use of in-network processing and data aggregation,
    - sensor nodes capabilities (communication, processing, storage and energy consumption) small delay and high throughput
  - the reliability of the link communication, namely error control and flow control
  - Addressing and routing and forwarding mechanisms (broadcast and multicast operations)
  - The data-centric networking approach
    - content-based addressing, geographic routing
  - Transport layer reliability (TCP over WSN)
  - The exploitation of location information
  - Advanced applications and security
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4- A prospective analysis of access networks

- The situation of communication network
  - A multiplicity of alternative technologies
  - Mobility, seamless service, expecting QoS
  - Multiple kinds of terminals, each with different characteristics

- Evolution factors
  - A cornucopia of technologies – DSL, FTTH, Wifi, Bluetooth, Wimax ...
  - Market (r)evolution - Triple-Play offers (telephony, data and video) is obviously very disruptive
  - Market regulation
  - Usage evolution - peer-to-peer (P2P) audio/video file sharing → ?? (personal blogs, home TV, home video control, and very dense games on line.....)
4- A prospective analysis of access networks

- Prospective on access technology, deployment and usage
  - Impact of market on access technology
    - competition between cablo-operators and telecom operators
  - Passive Optical Networks (PON) based access
    - the downstream traffic can be broadcast, while the upstream traffic requires a contention mechanism to share the medium
  - Metro, the new frontier
    - deploy service head-ends closer to the clients
  - Dumb network or smart network
    - Smart: every user is known by a profile which is consulted for optimizing the service delivered by a globalized service provider (P2P techniques)
    - Dumb: SKYPE, its own smartness
5- Wireless networks evolution

- The vision
  - ubiquitous computing and communication services, anywhere, anytime and on any device.
  - always best connected, moving seamlessly and securely between different networks and technologies, and demand access to high-fidelity broadband services whenever possible
- Requirement
  - new radio technologies that exploit the spectrum efficiently to increase coverage and capacity in a flexible and cost-effective manner
  - novel communication protocols that fully utilize the offered bandwidth
  - multi-access networking technologies
  - applications that can cope with high variability in connectivity
5- Wireless networks evolution

- Embedded revolution:
  - wireless connectivity is becoming a natural feature of more and more electronic devices, while tiny sensors, actuators and RFID tags are becoming embedded in the environment to offer interaction with the physical world. (autonomous and invisible information infrastructure)
5- Wireless networks evolution

- Managing the wireless melting pot
  - efficient utilization of multiple coexisting wireless access technologies
  - multiple radio technologies, different business models, dynamically and simultaneously connect
  - admission control, service selection and radio resource management on a multi-radio multi-operator context (authentication, authorization, accounting, mobility support ...)

- Stretching the limits of wireless by resource-efficient networking
  - spectrum efficiently to expand coverage and capacity in a flexible and cost-effective manner
  - dynamic spectrum access principles, cognitive radios
Engineering the seamless high-fidelity user experience
- Seamless services
- providing open support for high-precision localization

Designing the networking support for the embedded revolution
- The majority of devices will use wireless access and thus contest with other devices for (mostly unlicensed) spectrum.
- The traffic generated by these embedded devices is very different from the traffic we see in today’s network.
The mobile terminal (MT) will perform a set of procedures such as
- access discovery,
- access choice (metrics definition based for example on QoS, price, robustness and trust, policies based on user predefined preferences, etc.),
- registration/deregistration,
- authentication, authorization and accounting (AAA),
- profile handling, content adaptation, and attach/detach, among others …

Implementation of an Always Best Connected (ABC) solution will allow mobile terminals of next-generation wireless networks to choose the most suitable radio access technology at any instant of time during the whole duration of the session or call.
- Each technology has its own mobility architecture. (IP micro mobility)
Vertical handovers should be performed due to economical conditions or because of geographical scenarios.

- Handover as seamless and as fast as possible (all-IP world, interoperation)
- Evolved location, mobility and management handoff algorithms (based on motion prediction for avoiding the waste of resources, based on the information theory as a model of the uncertainty of mobile future localization)
- Innovative admission control mechanisms and QoS adaptation
- Location management databases (distributed, centralized)
- User multi-homing
7- Optical Access Networks

- Star or tree topology, point-to-multipoint communications where the central node or head-end controls the medium access of the end users.

- The downstream channel (from head-end to end user) is broadcast and upstream channel is shared among users. – xPON
  - xPON: TDM, two optical channels, Provision of different categories and service classes, transmission rates around 1 Gpbs, The service provisioning and network management are centralized, OLT should perform a translation of the access format to the other environment.
Mid-term/long term evolution & Open Problems

- The access protocols will be based on a combination of time, frequency and code multiplexing. (DWDM, DWDM-CSMA-CA, WDM-TDMA-CDMA)
- Full bidirectional transmission
- New modulation schemes: FSK/IM.
- New switching schemes: circuit switching, optical burst switching, packet switching or hybrid switching
- New ranging and synchronization mechanisms
- The information encapsulation techniques for achieving a high degree of transparency
- Centralized and Distributed resource management
- new Operational, Administration and Maintenance mechanisms and recovery algorithms that supply high network availability
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The role of optical network is crucial for providing aggregation nodes, re-configurable add-drop multiplexers, and optical cross-connects, in the different network segments, such as access, metro, core, and long distance networks.

- **High-speed transmissions**
  - increasing the number of wavelengths that can be carried on a fiber, increasing the transmission span, by means of amplification techniques, and improving the performance of a system as a whole

- **Reconfigurable optical add-drop multiplexers (ROADM)**
  - increase network flexibility, realization

- **Technologies for integrated devices**
  - lowering realization costs
  - Glass-on-Silicon
8- Optical Networking in core and metropolitan area networks

- Aggregation and routing nodes for optical networks
  - handle a huge amount of heterogeneous traffic
  - PW3 (pseudo-wire emulation edge-to-edge) : emulating circuit on packet switched networks
- Optical switching
  - the basic elements of optical cross-connects (OXC)s
  - high speed analog electronic switches and real optical switches
- Optical packet switching and optical burst switching
From unified towards integrated control, the GMPLS challenge

- Generalized Multi Protocol Label Switching (GMPLS) has created the foundation of the unique candidate for a unified control plane.
- GMPLS allow usage of identical semantics and common protocols for various data plane technologies from packet to fibre.
- The GMPLS challenge is to migrate existing technologies aiming at surviving on their own in order to achieve actual end-to-end collaborative control (horizontal integration) and multilayer operations (vertical integration)
9- New generation control planes, GMPLS

- Horizontal integration
  - Ubiquity, Mobility, Context Awareness, Location based services
  - Vertical roaming – seamless handover
  - GMPLS which is by nature a Connection Oriented (CO) technology had to participate to the set of protocols enabling inter-domain operations.
  - Limitations: the inter-domain routing richness and scalability (BGP), the inter-carrier restricted relationship

- Vertical integration
  - Multi-layer networks
  - Unified control and management planes
  - The overlay control plane interconnection model was designed for carriers or (bandwidth service) providers leasing their network facilities to Internet Service Providers (ISPs).
  - Multi Region Networks (MRN) represents the ultimate level of integration, MRN gives the capability for a single controller to handle multi-layer capable nodes.
Missing End-to-End enabler: the emerging Path Computation Element-based architecture

By analogy to the decoupling of TE and strict routing topology processing in intra domain, the PCE-based architecture proposes to introduce functions positioned between control and management planes enabling intelligent inter-domain networking.
Summary

Objectives:
- Ensure coverage and connectivity
- A main keyword: convergence
- Future communications will view multi-service/multimedia, generalized mobility, services convergence, ubiquity, context awareness and always best connected, security, self-organization, transparency and virtualization as the norm