Telecom Italia Network

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TILab – Data Networks Innovation
Group’s business units and main brands
Telecom Italia LAB

Competence center for Telecom Italia Group’s research and development activities, taking over Telecom Italia Lab’s resources and know-how:

- Pilots technological innovation, new technology scouting, surveys, feasibility assessments and research into prototypes
- Areas of operation: fixed-line and mobile access network design and development, transmission network upgrades, service and platform development, next-generation terminal design and testing

- Resources
  1187 employees, 65% graduated
  (April 2012)

- Patents
  more than 2000’ already registered

- Labs
  over 12000 m²

- Sites
  Turin, Milan, Trento, Rome and Naples
TILAB – Transport and Data Network

- Network deployment of the new photonic backbone with 40Gigabit/s interfaces and ROADM technology
- Design and testing of IPv4 Network Address Translation solutions
- Studies and prototyping of advanced network solutions for the backhauling of LTE on the metro-regional network and deployment of IPv6 in the network
- Study and prototyping solutions SDN (Software Defined Networking)
- Technical evolution for Sparkle backbone
- Transport solutions to 100 Gigabit/s
- Engineering and deploying new radio solutions for transport and backhauling
Agenda

► General Network Architecture
► Optical Packet Backbone (OPB)
► Access Network
► OPM
► PoP
► Differentiated services where and why
General Network Architecture
General principle in network design

- Network architecture design starts from some aspects that are hard to change...
  - Traffic matrix
    - Dramatically changed in the last 10 years:
      - voice vs data
      - Increase in volume, loose on locality
  - Topology and available infrastructures
    - Buildings, conduits, cabinets, ...
    - Optical fiber in the backbone and in the distribution network
    - Copper cables in the distribution network
- Typical goals of a network architecture design are
  - Minimum congestion
  - Maximum availability
  - Minimum cost
  - Maximum utilization
- Networks continually evolve
  - Dimensioning and QoS are complementary tools
From Telephone network to Data Network

**Infrastructure Onion**

- **Small/very small SL**
- **SL**
- **SGU**
- **SGT** ~30
- ~ 500
- ~ 2000
- ~ 10000
- ~ 150000

**Traffic Matrix**

- **International**
- **Backbone**
- **Area A**
- **Area B**

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**Infrastructure Onion**

- **Cabinet**
- **ONU**
- **Digital divide**
- **DSLAM**
- **Eth Agg.**
- **POP** ~30
- ~ 500
- ~ 6000
- ~ 10000
- ~ 150000

**Traffic Matrix**

- **Internet**
- **Backbone**
- **Area A**
- **Area B**
**TI Network architecture**

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Other Operators

INTERNET

Backbone

Aggregation and transport

Access network

Other Operators

INTERNET

Backbone

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Other Operators

INTERNET

Backbone

Aggregation and transport

Access network
Optical Packet Backbone
OPB, a single IP/MPLS Multiservice Backbone

IP/MPLS transport for:

**Data Services:**
- **Internet Access**
- **Public IP national transport for fixed and mobile services**
- **VPN MPLS**
- **IP-TV**
- **IPv6 with 6PE architecture**

**Voice Services:**
- **Class4 and Class5**
- **Business & Residential**
- **Mobile**
Evoluzione di OPB

1995 - 2000
12 PoPs; Link E3 e E1

2001 - 2004
32 PoPs: 4 Inner Core e 28 Outer Core
diffserv QoS, MPLS TE e VPN; GSR
technology
STM-1 e STM-16 links; STM-64 in IC
POP

2005 - 2007
CRS technology in IC and main
OC POPs, 10Gbps links; first 2
POP @ 2x10Gbps

2008 - 2012
-OPB²+
-PB³+

40Gbps and MultiChassis tech in IC
CRSs - CRS technology in
secondary OC POPs;
moren x 10Gbps links
GSR nodes used as gateways for
BBN, VoIP and Further Core POPs

The Future…
Current OPB architecture

Offloading

INNER CORE

TO/FROM POP

INTERNATIONAL GATEWAY

POPs principali (8)

POPs secondari (20)

Inner Core (4 POPs, 2 in RM & 2 in MI)

Outer Core
New Photonic backbone

- **Network diameter**: 2400-3100 km (working-protection)
- **Maximum number of hops**: 11
- ~40 ROADM
- ~60 DWDM ULH systems with 80 lambdas
- 10 and 40 Gbit/s Optical Channel (OCh)
- 100 Gbit/s ready
Access Network
Broadband Access network

- 112.6 million of km pair of copper access network

- With the “Anti Digital Divide project”, launched in 2006, today Adsl coverage reached around 97% of the national territory

- Different generations of DSLAMs
  - ATM based with 155 Mbit/s network interface
    - ADSL1 up to 8 Mbit/s DW, 1 Mbit/s UP
    - ADSL2+ up to 20 Mbit/s DW, 1 Mbit/s UP
    - ~ 6000 SL with fiber
    - ~ 2000 SL with copper (max 640 kbit/s)
  - QoS ATM based -> on congestion discarding cells, very difficult to relate to the applications
  - Ethernet based with 1 GE network interface
    - ADSL2+ only
    - ~ 4500 SL with fiber
    - Qos based on Ethernet, normally at least 4 queues

- 7 million retail broadband customers
Moving to Ultrabroadband

- 4.9 million of km – fiber of access and carrier network
- FTTH solution based
  - GPON with 1:64 splitting factor
  - pt-to-pt for business
- FTTCab
  - Extension to existing cabinet
  - 48 VDSL2 ports from the cabinet
Bottleneck are in the access...

► Even if the total capacity in the access is much greater than in the backbone, the access is the real bottleneck
  ► Limitation UP/DW due to the capacity of the subscriber loop
  ► Capacity of the links between the aggregation network and the DSLAMs
  ► Cascading of DSLAM
► Statistical multiplexing does not help so much
► Upgrading the capacity is complex and takes time
► Simple tools to discards packets in congestion conditions
Optical Packet Metro
OPM 1/2

- OPM project was launched in 2005, concurrently with the introduction of Ethernet DSLAMs.
- The network covers today more or less all the SGU sites (~ 500).
- SL sites connect to OPM through the transport network (SDH or in future PTN), the regional WDM network or dark fiber.
- OPM is a multiservice network:
  - Fixed broadband aggregation
  - IPTV
  - Mobile backhauling
  - Ethernet end-to-end services
  - ATM transport
- Initially based on Ethernet technology is moving to MPLS to increase scalability and decrease the convergence time on failure.
**Bitstream service**

![Diagram of Bitstream service](image)

- **GE** = Gigabit Ethernet
- **OLO** = Other Licensed Operator
- **PoP** = Point of Presence
- **VLAN** = Virtual LAN

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*Politecnico di Torino "Network management and QoS provisioning"*

*Telecom Italia Fixed Network*
POP
Broadband Network Access Server (BNAS)

- Residential and SOHO customers
  - Retail: Internet Access, Internet Access + VoIP
  - Wholesale
- 20-100K customers per box
- Point-to-Point VLAN to Access Nodes (PPPoE for customer separation)
- RADIUS protocol for communication with AAA servers
- Per session Authentication based on “loop ID” (and Username and Password)
  - Dynamic configuration of a Virtual Interface per customer based on service profile (including Access Control List, Rate limiting, QoS, VPN, IPv6, ...)
  - Address assignment
- Per session Accounting
  - Time based services
  - Legal documentation requirements
  - Collection of statistics
- High CPU usage due to authentication and accounting
Provider Edge (PE)

- **Business and TOP customers**
  - Internet Access, L2/L3 VPN, VoIP
- **2-10k customers per box**
- **Strong SLA (i.e. maintenance operations only during the night)**
- **Point-to-Point VLAN to Access Nodes (Q-in-Q for customer separation)**
- **MPLS on interface backbone side**
  - solution for providing both Internet Access and L2/L3 VPNs (and for adding IPv6)
- **BGP protocol used to monitor the status of the link between the PE and the CE**
  - In case of failure backup connections are activated in less than 30s
  - New solution based on Bidirectional Forwarding Detection (BFD): less CPU intensive, more reactive
- **High CPU usage due to routing protocols**
Work in progress: dual homing
Differentiated services where and why
**Preventive Action: bandwidth over-provisioning**

- **OPB and OPM network design** remove single point of failure
- **All internal links are dimensioned following the 50% rule**: each link can’t be loaded by more than 50% of its capacity at the peak hour
- **Warning thresholds are defined** to allow planning for upgrades
- **Continuous monitoring of the link load**
- **In a common operational situation**, all traffic can cross the network with a minimum delay and with the maximum quality available.

![Network Diagram](image)
QOS implementation in internal links of OPM and OPB

- Differentiated Service Model can be useful to protect critical traffic in case of multiple simultaneous faults
  - Classification based on IP precedence, MPLS EXP or Ethernet CoS
  - 3, 4 queues: a strict priority (typically for voice) queue and 2, 3 WFQ for different data classes

- Critical point is traffic marking:
  - You cannot trust IP precedence of Internet IP packet...
  - ... most of the traffic in the backbone is in the Default class
Qos on PE 1/2

- For a business access 3 parameters are defined:
  - A peak bandwidth
  - A Minimum Guaranteed Bandwidth (BMG): the minimum bandwidth that will be available also in congestion conditions
  - The Real Time Bandwidth (RTB): the maximum traffic that is allowed in the Low Latency Queue

- For each access the PE applies a limitation of the peak bandwidth at the maximum value defined by the selected offer (e.g. 2 Mbit/s)
  - Peak bandwidth is usually equal to the bandwidth available on the local loop
  - However it may happen that the local loop bandwidth is lower than the peak bandwidth: differentiated queuing at the DSLAM level is still required to avoid discarding of critical traffic

- For each access the PE marks packets according to the BMG
QoS on PE 2/2

- 3 queues for each access
  - LLQ+2WFQ (Mission Critical and Default)
  - Example of weights is 30:70
- Hierarchical queuing
  - multiple access on a single interface
- In case of congestion the bandwidth is distributed through the different accesses proportionally to the BMG parameter
QoS on BRAS

- For a residential PPP a peak bandwidth is defined
- For a SOHO PPP session also a BMG is defined
- The BRAS applies a limitation of the peak bandwidth at the maximum value defined by the selected offer (e.g. Alice 7 Mega, Superinternet, ...)
- If BMG is defined, the BRAS marks packets accordingly
- For each customer we have 1 or 2 queues (LLQ and default)
- Hierarchical queuing
- In case of congestion the bandwidth is distributed through the different sessions proportionally to the Peak bandwidth and the BMG parameters