QoS and QoE in the Next Generation Networks and Wireless Networks

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Quality of Service

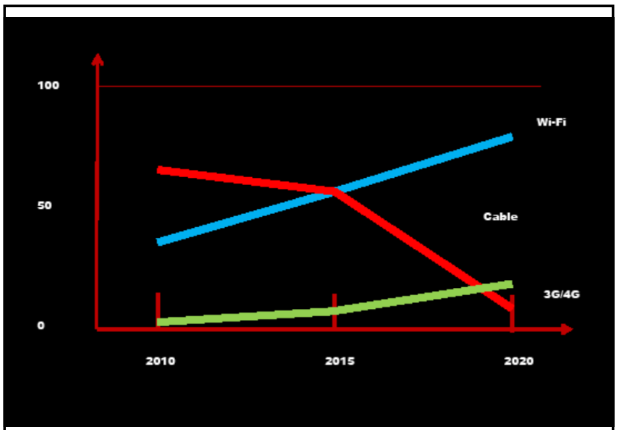
- QoS for a network: different parameters such as bandwidth, latency, jitter, packet loss, packet delay
- for video applications: QoS is based on the bandwidth
- for VoIP: QoS is based on latency (end to end delay not larger than 200 ms)
- =>optimize delay, bandwidth, packet loss… but not all

- CoS (Classes of Service) classify the services in different classes.
- CoS manage each type of traffic with a particular way
- ETSI (European Telecommunications Standards Institute has introduced 4 CoS (Classe 1 : Best Effort, Classe 4: QoS guaranteed)
- QoE (Quality of Experience): subjective measure of a customer's for a supplied service
- Many SLA offers 3 CoS: Premium (max 15% of network resources), Olympic (max 80% of network resources) and BE

- QoS can be linked to the
  - network level: QoS depend of the network policy. Mechanisms such as filters, rerouting in the core of the network and control access at the corners of the network. Intelligence in the routers. (OSPF, RIP, SNMP, BGP)
  - application level: applications which improve the QoS. No link with the network infrastructure. (NFS, …)

- **Internet is increasing exponentially:**
  - **2001: 180 million users**
  - **today: more than 2 billions users**
- **Internet traffic and the bandwidth double every 18 months**
- **The bandwidth is about 100 Tbits/s**
- **More wireless voice traffic than wired traffic**
- **=> non-packet based traffic are encapsulated in data packet traffic (Internet)**
- **=> Multiple access technologies (ADSL, 3G, …)**

- CTI (Computer Telephony Integration)
  - PC: intelligence in the computer
  - telephony: intelligence in the network
  - => to reach a compromise
- Switched telephony network (TDM) => IP NGN networks (Multiservices Convergent Network)
- Modem triple play (voice, data, TV)
- Quadruple play: triple play + mobile telephony (Wifi and 3/4G)
- Virtualization of the access point. Green networks
- IMS (IP Multimedia System) architecture: full IP architecture



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New Communication architecture

- Challenge : offer QoS in the Internet network
- Multimedia applications, VoD, IPTV for Internet will be developed and used when QoS mechanisms will exist
- New functions must be developed to guarantee performance, offer security, avoid jitter, allow the respect of time-constraints, ...

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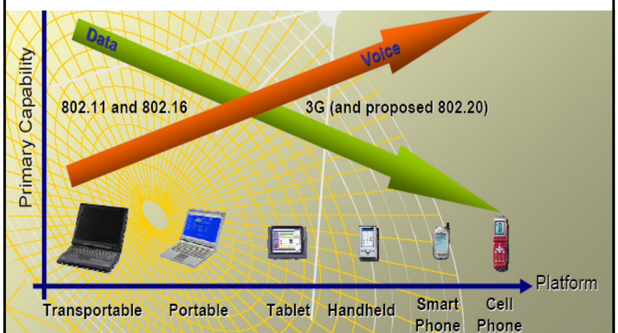

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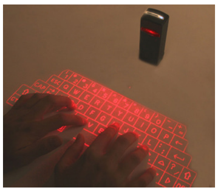
Flexible Organic Light Emitting Diode (OLED) – Holographic / Laser keyboard



- 2 types of applications: elastic (TCP) or streaming (RTP/UDP)
- 90% TCP - 10% UDP (no congestion control mechanisms)
- WWW: 75% Email: 3%
- FTP: 4% News: 7%

- Best Effort: provide a fair service
- Max-min allocation of bandwidth: maximize the bandwidth allocation to the source receiving the smallest allocation
  => decrease the bandwidth allocated to other source
- Packets are dropped when congestion occurs in routers
  - when the buffer is full (tail drop)
  - when the buffer occupancy increases too much (RED Random Early Detection)

- Congestion control mechanisms in end systems
  - Inform the source about network congestion with ICMP or tagged packets with ECN (Explicit Congestion Notification) => all routers should implement the congestion control mechanisms
- Divide the output buffers in N queues and introduce a scheduler (processor sharing, round robin)

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- Classification of the IP flows at different layers: edge router perform classification/marking and backbone router relies on marking
- Weighted RED: n RED algorithms in parallel. Support n drop priorities to offer minimum bandwidth service
- Generalized Processor Sharing/Weighted Round Robin: introduce a weight to each queue

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- New communications network must offer:
  - QoS
  - Mobility
- => necessary to introduce
  - QoS mechanisms with signaling and routing solutions (telecommunication world)
    - Switching: distributed (MPLS) or centralized (PDP)
  - Overprovisioning/priority the network for new applications such as TV on demand, telephony IP
    - Routing
- Overprovisioning is not a global solution but is an asset for traffic engineering and QoS in Internet

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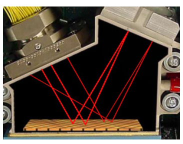
- Core of the network: architectures with signaling (SS7, X25/ATM, GSM, UMTS, NGN): QoS but expensive => UMTS 15000 $

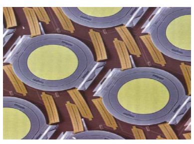
- with no signaling (Arpanet, Internet 1st and 2nd generation, WiFi): no QoS, but cheap => Wi-Fi 100 $

- Growth of the networks capacity: Wavelength Division Multiplexing (WDM)
  - 2005: 1000 Wavelength / 100 Tbit
  - ATM not possible with these rate
  - IP packet => IP frame (code violation)
  - IP over ATM over IP
  - all IP in the future Copper => optical

- 3rd generation
  - Intelligent platform with several IP WDM network

- optical switching
- 256 mirrors
- Diameter: 0,5 mm
- Micro Electro Mechanical Systems (MEMS)





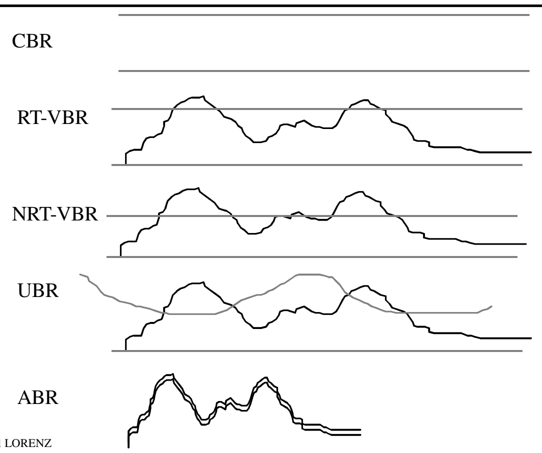
- Fiber To The Curb (FTTC)
- Fiber To The Building (FTTB)
- Fiber To The Home or (FTTH)
- Fiber To The Terminal ou (FTTT)

ATM networks

- Connection oriented protocol
- offer real QoS guaranty
- QoS is negotiated during the establishment of the connection and depend of the available resources

- 6 CoS:
  - CBR(Constant Bit Rate): guarantee a constant rate: videoconferencing, telephony
  - RT-VBR (Real-Time Variable Bit Rate): transmission with a variable rate for application requiring real-time constraints: MPEG transmission
  - NRT-VBR (Non-Real-Time Variable Bit Rate): transmission with a variable rate for application requiring no real-time constraints: multimedia transfer
  - ABR (Available Bit Rate): transmission of traffic using remaining bandwidth or bursty traffic. ABR guaranty always a minimum rate.

– GFR (Guaranteed Frame Rate): accept to loose sometime some services
– UBR (Unspecified Bit rate): no rate guaranty and no congestion indication. Best Effort.



Parameters

- QoS comes from the signaling mechanisms and stream controls
- QoS parameters are:
  - CTD: Cell Transfer Delay
  - CMR Cell Misinsertion Ratio
  - CLR: Cell Loss Ratio
  - CER: Cell Error Ratio
  - PCR Peak Cell Rate
  - MCR: Minimum Cell Rate
  - CVDT: Cell variation Delay Tolerance
  - SCR: Sustainable Cell Rate
  - BT: Burst Tolerance
  - CDV: Cell Delay Variation

MPOA

- avoid the router bottleneck problem
- introduce a route server used for the ATM address resolution
- can be considered as a virtual router which divide data transmission from computation functions
- I-PNNI is used instead of RIP and OSPF
- MPOA can be used in wide area network
- Router: + Intelligence - slow
- Switch: + speed - no intelligence

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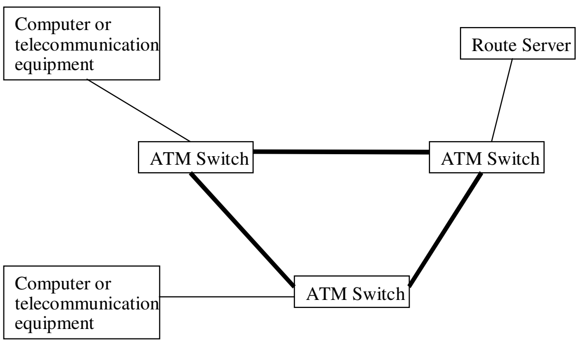

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Mechanisms allowing QoS

- 1996: proprietary solutions such as Tag Switching (Ipsilon), IP Switching and Net Flow Switching (Cisco), ARIS (IBM), IP Navigator (Cascade), ...
- Signaling (control, management) -> routers
- Data -> switchs

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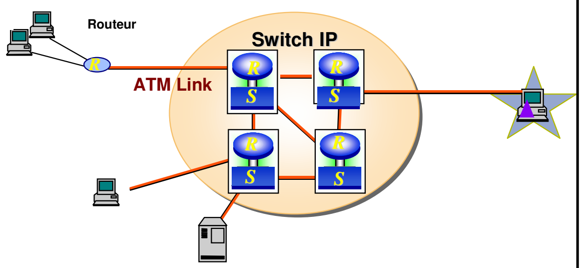

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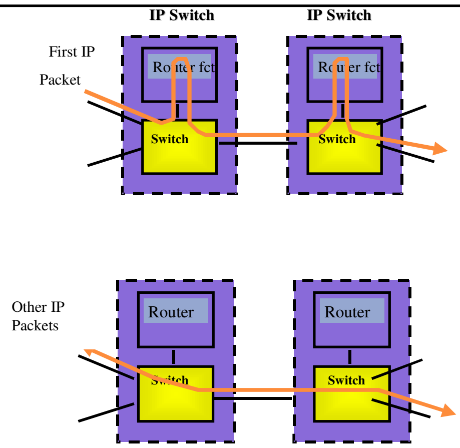

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- The control plane of ATM has been transferred to the IP layers
- IP: routing, signaling and the management of switching tables (20% traffic)
- ATM or Ethernet: only the fast forwarding at level 2 (80% traffic)

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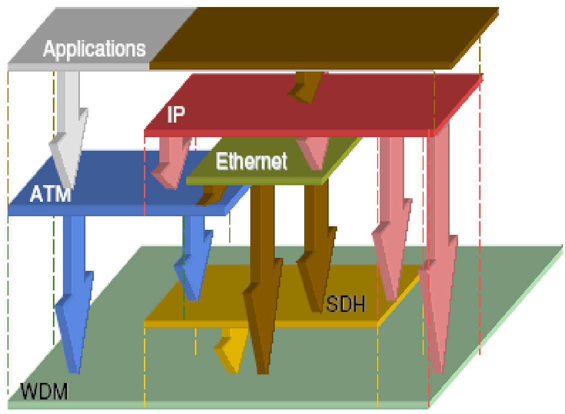
Transport Layer	IntServ, RSVP, DiffServ
Network Layer (IP)	MPLS
Data Link Layer (Ethernet, FR, ATM, PPP)	
Physical Layer (Sonet/SDH, optical fiber, 802.17: Resilient Packet Ring)	



MPLS (Multi Protocol Label Switching)

- Packet forwarding is based on labels
- Labels (4 octets) are assigned when the packets enter into the network
- The assignment of a packet to a FEC (Forwarding Equivalence Class) is done just once when the packet enters in the network at the ingress node, all packets with the same destination use a common route
- At the egress node, the label is removed
- The label is inserted between the layer 2 header and the IP header

Real time Transport Protocol and Real Time Control Protocol

- RTP: functions for real time applications
- RTCP: used for supervision and control information
- => QoS for voice and movies without jitter

Ressource ReSerVation Protocol

- Signaling protocol to establish unidirectional flows in IP networks
- RSVP is used by routers to deliver QoS
- RSVP request : reserve resources in each node along a path
- RSVP sends periodic refresh message to maintain the state along the reserved paths(s)
- The bandwidth is reserved for a given flow
- Require resources reservation and releasing at regular intervals

IntServ

- Based on traffic control mechanisms
- Signaling protocol: RSVP
- Reservation at the router level
- Poor scalability: the amount of state increase proportionally with the number of flows
- Problems:
  - all routers must have RSVP
  - there is no policy for the reservation control
  - stations must support signaling

=> small networks

DiffServ

- DiffServ is a relative-priority scheme
- Signaling protocol: SLA
- Specify contracts for few traffic classes
- IP Packets are classified and marked at the network ingress routers to create several packet classes
- Type of service is marked inside each IP packet
- DiffServ scalability comes from the aggregation of the traffic
- Utilize aggregate classification state in the core of the network
- Share the bandwidth => hierarchy of the different flows

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- DiffServ is more easy (less complex) to be implemented than IntServ, but give less accurately (less QoS flow differentiation) to the flows
- DiffServ: located in the core of the network between the routers
- IntServ: periphery of the networks. Work on micro-flows. Complex, "hard" approach for QoS.
- LAN: IntServ
- MAN: DiffServ (or IntServ)
- WAN: MPLS

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- Global Internet: GEO, MEO, LEO
- 4G: LTE-A
- 3G: UMTS, CDMA2000, …
- 2G: GSM, GPRS, EDGE, PDC, …
- Hot Spots: WiFi
- PAN: Bluetooth, Ad Hoc, …
- Wired networks: ADSL, PSTN, …
- => Multimedia mobile applications will create an united common platform that incorporate different services.
- => QoS (time, bandwidth, reliability, …) and security problems within heterogeneous networks

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QoS

- Terminals (batterie (hydrogen, supercondensator, …) , screen size, processor, ….)
- Blind spots
- Handover
- Each wireless networks offer different QoS

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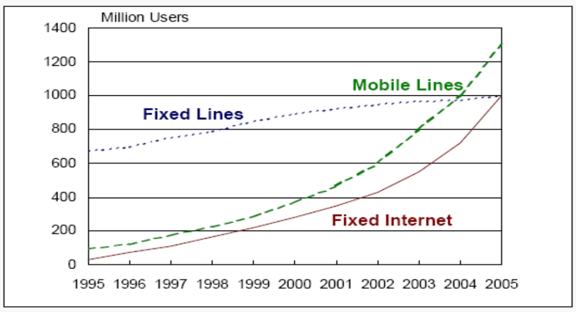

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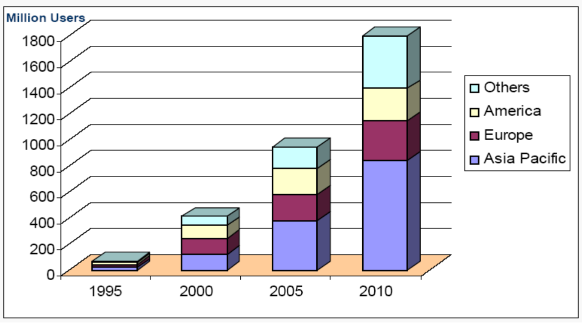

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Multiple Access Techniques

1G: FDMA (analogical)
2G: TDMA (numerical)
3G: CDMA
4G: OFDM (Orthogonal Frequency Division Multiplexing)

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Satellite Transponders

- LEO
(Low Earth Orbit) use the Ka band

- MEO
(Medium Earth Orbit),

- GEO
(Geostationary Earth Orbit).

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- Pico-satellite: 1 kilo, 340 km
- HEO (Highly elliptical Earth Orbit)
- HAPS (High Altitude Stratospheric Platform):
  +Proteus airplane (Awacs) will offer a bandwidth of 164 kbit/s for a 100 km diameter
  + Airship at an altitude of 23 km (Sky Station project). Rate of 10 Mbit/s in the 48 GHz band.

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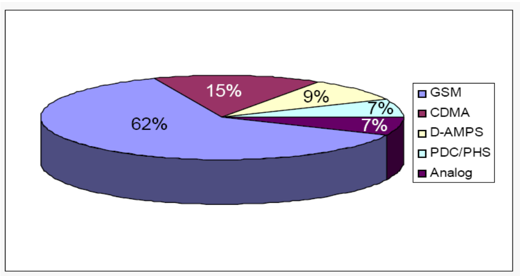
Telephony



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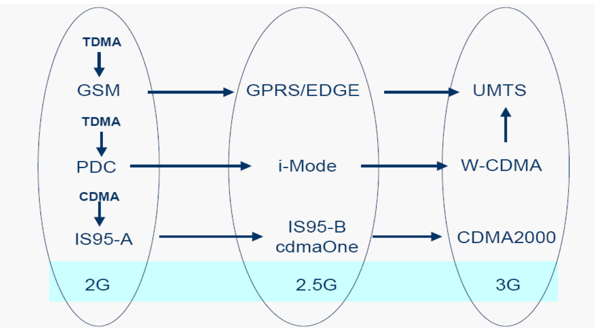

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2,5G:

- GPRS (General Packet Radio Service): rate of 48 kbit/s
- packet switching
- cost of the communication is based on the amount of data
- without modification of the BSS: same frequency of the GSM
- reuse the BTS and the BSC

2,75 G:

EDGE (Enhanced Data rate for GSM Evolution): rate of 150 kbit/s

E-GPRS (Enhanced GPRS): apply EDGE to GPRS

- **New frequency and new infrastructures**
- **3G UMTS: 384 kb/s**
- **3,5G: HSDPA (High Speed Downlink Packet Access) => 1Mbit/s**
- **3,75G: HSUPA High-Speed Uplink Packet Access => 4 Mb/s**
- **4G: 2010 will use the 30 GHz frequency : 300 Mb/s**
LTE-A (Long Term Evolution)
-5G: =>2020

IEEE 802 wireless standards

- 802.15 WPAN, since 1999 (RFID, ZigBee, Bluetooth, UWB, Wimedia)
- 802.11 WLAN, since 1990 (WiFi)
- 802.16 WMAN, Wireless Local Loop, since 1999 (WiMax)
- 802.22 WRAN

- There is no single technology that can satisfy all needs . Family of complementary technologies and devices

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Wireless Personal Area Networks (WPAN) IEEE 802.15

- RFID (Radio Frequency Identification)
- IEEE 802.15.1 : Wireless Personal Area Network (Bluetooth). Rate 1 Mbit/s, 2400MHz. 10 meters
- IEEE 802.15.3: High rate 400 Mbit/s WiMedia Ultra WideBand (UWB) is a wireless technology for transmitting digital data over a wide spectrum of frequency bands with very low power, WUSB (Wireless USB) => 480 Mb/s
- IEEE 802.15.4: 200 kb/s, communications between toys, sensors (ZigBee), low complexity, low power consumption

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Wireless LAN (WLAN)

- IEEE 802.11b (WiFi – Wireless Fidelity): frequency 2.4 GHz, rate 11 Mbit/s, 100 meter, 2 walls CDMA/CA, 14 channels
- IEEE 802.11g: 2.4 GHz, 54 Mbit/s, compatible with 802.11b
- IEEE 802.11a : 5 Ghz, 54 Mbit/s (WiFi 5), 1997
- IEEE 802.11i : security (EAP: Extensible Authentication Protocol), WEP, TKIP, WPA
- IEEE 802.11e : QoS
- IEEE 802.11f : handover
- IEEE 802.11n: power control, High throughput WLAN (300 mb/s), (e+f+i) 2,4 et 5 Ghz
pre-n: MIMO (Multiple Inputs Multiple Outputs)

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New IEEE 802.11 ng projects

- 802.11k for radio resource management to achieve optimized use of radio resources
- 802.11r – Fast roaming
- 802.11s – Mesh networks (improving WiFi with AdHoc) => mobile hotspot
- 802.11u – Wireless Interworking with External Networks (WIEN)
- 802.11ah 1km smartgrid. Slow
- 802.11af Cognitive radio 10 or 20 meters (Utilization of TV frequencies)
- 802.11ac – Beamforming <6Ghz 500 Mb/s. Directional transmissions
- 802.11ad - Very High Throughput in 60 GHz 10 meters. WiGig (Wireless Gigabit Alliance) => 6 Gbit/s

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Wireless Local Loop (WLL) & WMAN (Wireless Metropolitan Area Network) IEEE 802.16

– WiMax standard: 10 Ghz to 66 Ghz, 50 km and 120 Mbit/s
(Plug & play) => equivalent and compete with DSL, can connect 802.11 hotspots, transmit voice, IP, … with security
- WiMax-Mobile (IEEE 802.16e ex IEEE 802.20) 3,5 Ghz 1Mbit/s 250 km/h

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Next Generation Internet

- MPLS, Native IP, Carrier Grade Ethernet
- Unique network: wired and wireless, data, voice
- Problem of TCP/IP: electrical consumption, complexity
- Intelligence in the network: smart, active autonomic networks => autoconfiguration
- Vitual Internet: Cloud and Data Center

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THANK YOU - Question ??

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