IPTV QoE:
Challenges for the IP network

End-to-End QoE/QoS Workshop. Geneva, 14-16 June

- IPTV QoE framework and requirements
- IP Transport requirements
- IP backbone and access loss patterns
- Error recovery

A Glance to Fastweb IPTV Services

- Broadcast TV and VoD service offered commercially since 2001 (since 2003 over ADSL)
- About 100 TV Channels (the infrastructure supports many more)
- More than 5000 contents archived and available through VoD portals
  - Not only movies: fictions, news, music, documentaries
- Network PVR
- Video content (VoD or TV) up to 4 Mbps MPEG2 streams
- Digital Dolby 5.1
- TV: centralized multicast transport, VoD: unicast regionalised transport
- 180.000 Video customers
- One of the largest IPTV operators in the world

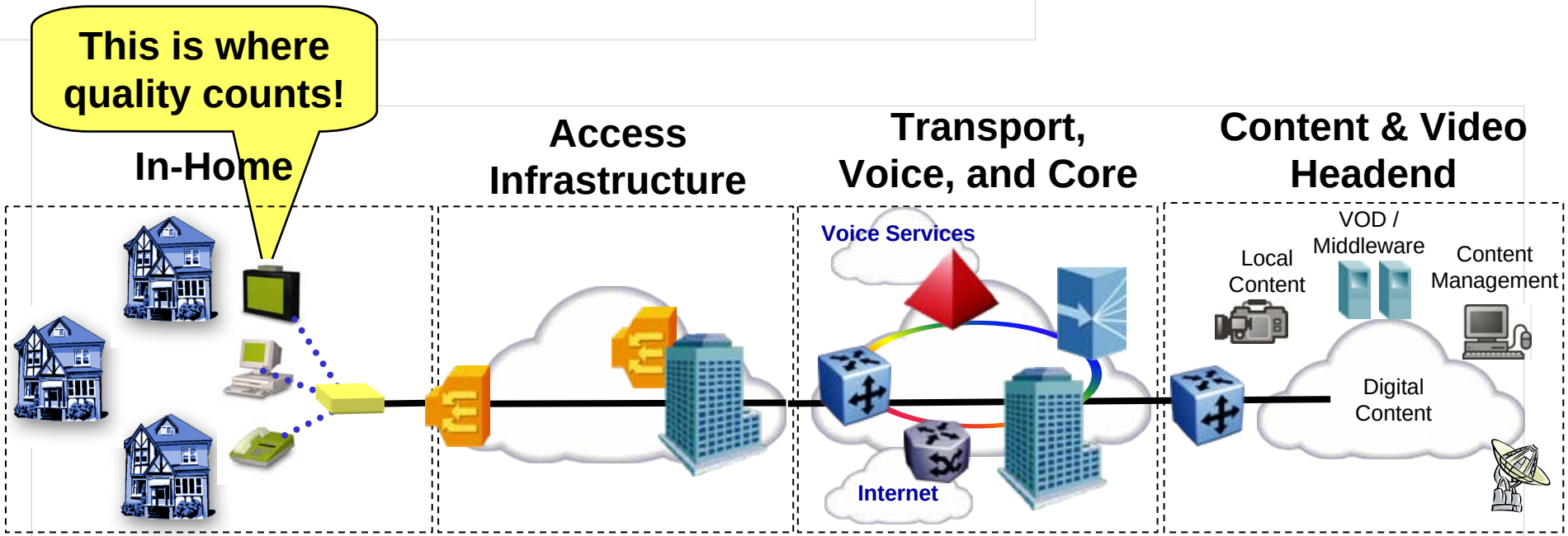
QoE and QoS

QoE	Quality of Experience (QoE) **describes the performance of a device, system, service, or application (or any combination thereof) from the *perspective of the user*.** • **QoE measures how well a network service satisfies the user's expectations and needs**
QoS	• **Quality of Service (QoS) refers to a set of technologies (QoS mechanisms) that enable the network administrator to manage the effects of congestion on application performance as well as providing differentiated service to selected network traffic flows or to selected users.** • **QoS mechanisms do not create bandwidth but instead manage available bandwidth more efficiently, especially during peak congestion periods**

QoS is a measure of performance at the packet level from the network perspective. QoE is a measure of end-to-end performance at the services level from the user perspective.

Courtesy of: Nortel, Tim Rahrer

Video Service QoE Engineering



- **Define the variables contributing to satisfactory service QoE – transport and video application layers**
- **Model end-to-end network to determine impacts on service quality**
  - **Model tradeoffs in service features with network capabilities**
- **Define network performance requirements to achieve target QoE**
- **Define measurement methods to verify QoE**

Need a complete end-to-end view and user needs to ensure network architecture and service success

Courtesy of: Nortel, Tim Rahrer

QoE and IP network requirements

- A subset of user experience requirements for SD IPTV:
  - Same video quality as the user is normally used to through other means of distribution (Satellite, terrestrial, cable)
  - High availability and continuity of the service
  - Very low visible impairment (error) rate – how low?
  - Channel Change time comparable to what the user is used to

- These requirements will translate (also) into requirements for the network and IP transport layers:
  - Minimum IP end-to-end bandwidth available for IPTV (Ex: 4 Mbps for SD)
  - IP QoS support to handle congestion
  - End-to-end IP Transport performance objectives for:
    - Packet Loss
    - Delay
    - Delay variation

Based on field experience:

TV users may not complain or open a ticket for each error they notice… but they always compare what they get through IP/DSL with traditional broadcasting service, and based on this may decide whether to subscribe or confirm subscription:

- Input in the network good enough quality video
- Preserve it throughout all the IP delivery chain

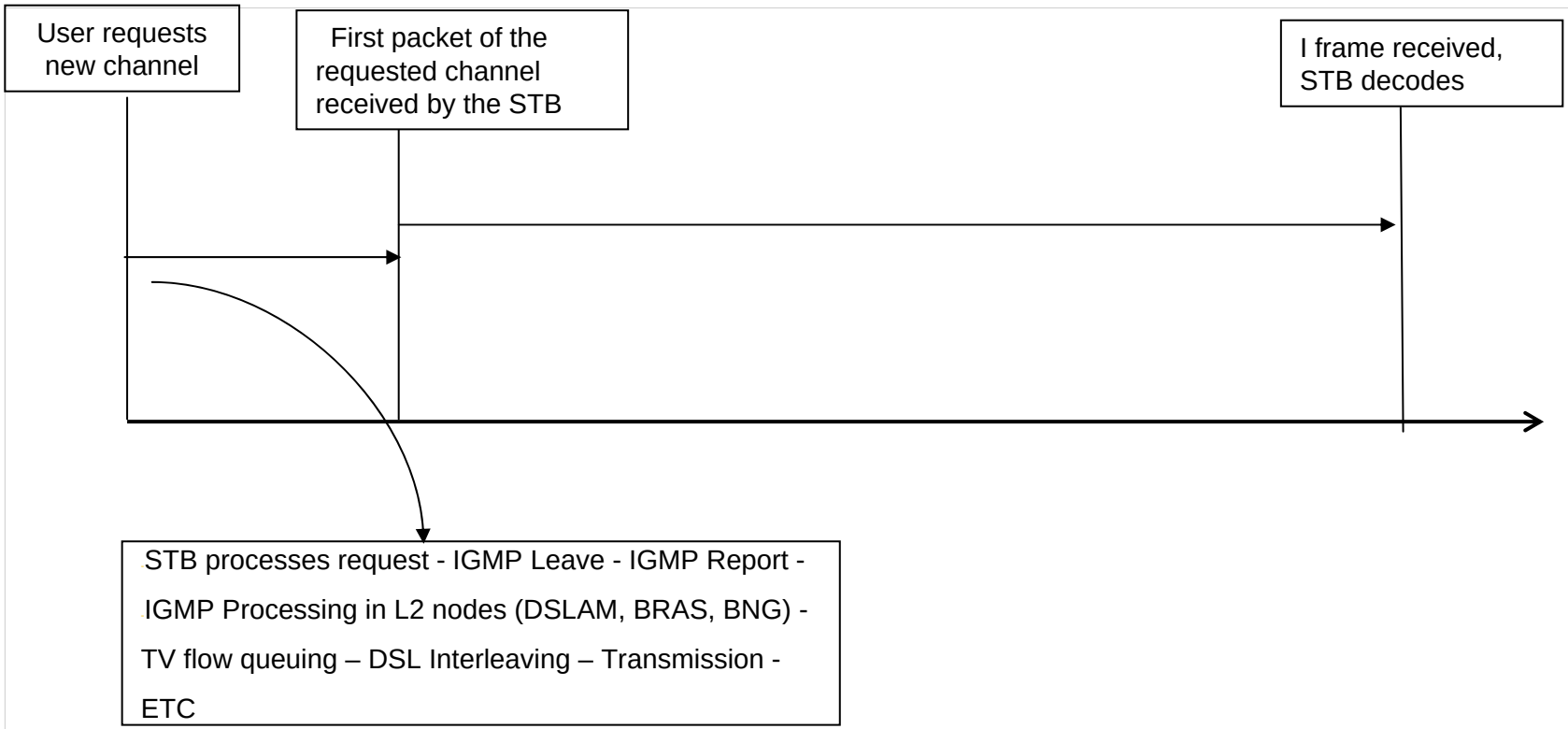
IP Transport performance objectives
Delay

By far the most important parameter that affects the IPTV service quality is the IP packet loss, indeed:

- The delay introduced by a well performing IP network (say up to hundreds of milliseconds for a huge geographical network) is usually negligible for the IPTV service considering that:
  - IPTV is still mainly a unidirectional service with some loose interactivity requirements (channel change, video portal and content access, pause, play, etc. for VoD)
  - Most of the delay from the live content will be added from the Head-end and video acquisition/coding/transcoding chain
  - Current satellite broadcast TV service already may insert a delay up to a few seconds
  - Delay in Channel Change time due to network transfer delay signalling processing (IGMP Leave/Join signalling and first packet reception of the requested channel for multicast service) is negligible (up to few tenths of milliseconds) when compared to the time needed to the STB to buffer enough video content for a smooth start for the play out .This time is usually comparable to a GOP interval which for 4 Mbps MPEG2 video streams is about half a second

IP Transport performance objectives
Channel change - Delay variation

- **Channel Change:**



- **Delay Variation:**
  - Because of the presence of a quite large play-out/de-jitter buffer at the receiving side (STB), all potential jitter introduced by a well performing IP network is removed for a smooth play-out and virtually no packets is lost due to late arrival.

IP Transport performance objectives
Packet Loss

- IPTV service is highly sensitive to packet loss
- Although the impact of a single packet loss depends of several factors such as:
  - Compression algorithm (MPEG2, H.264, etc.)
  - GOP Structure
  - Type of information lost (I,P,B frame, other MPEG information, etc)
  - Codec performance (encoding and decoding)
  - Complexity of the video content
  - Error concealment at the STB
- It is highly likely that a single IP packet loss produce a visible impairment to the user – Note that a single IP packet usually transports 7 188 Byte MPEG packets

- **Packet loss has to be minimized and strictly controlled:**
- **Simple metrics as average Packet Loss Ratio are not enough to describe the packet loss requirement**
- **→ what matters is the loss event, its rate (MTBE) and shape (loss period and distance), not only the ratio lost_packets/received_packets.**

IP Transport performance objectives
Packet Loss - 2

- As an example:

	4 Mbps SD stream (MPEG2) → 380 pps	12 Mbps HD stream (H.264) → 1140 pps	Quality
Single packet loss in 30 minutes	**PLR= 1.46*10-6**	**PLR= 4.87*10-7**	**Likely Good**
Single loss event of 10 lost packets in 30 minutes	**PLR= 1.46*10-5**	**PLR= 4.87*10-6**	**Likely Good**
10 single packet loss events in 30 minutes	**PLR= 1.46*10-5**	**PLR= 4.87*10-6**	**Likely noticed by the user**

Ideal target: 0 loss.

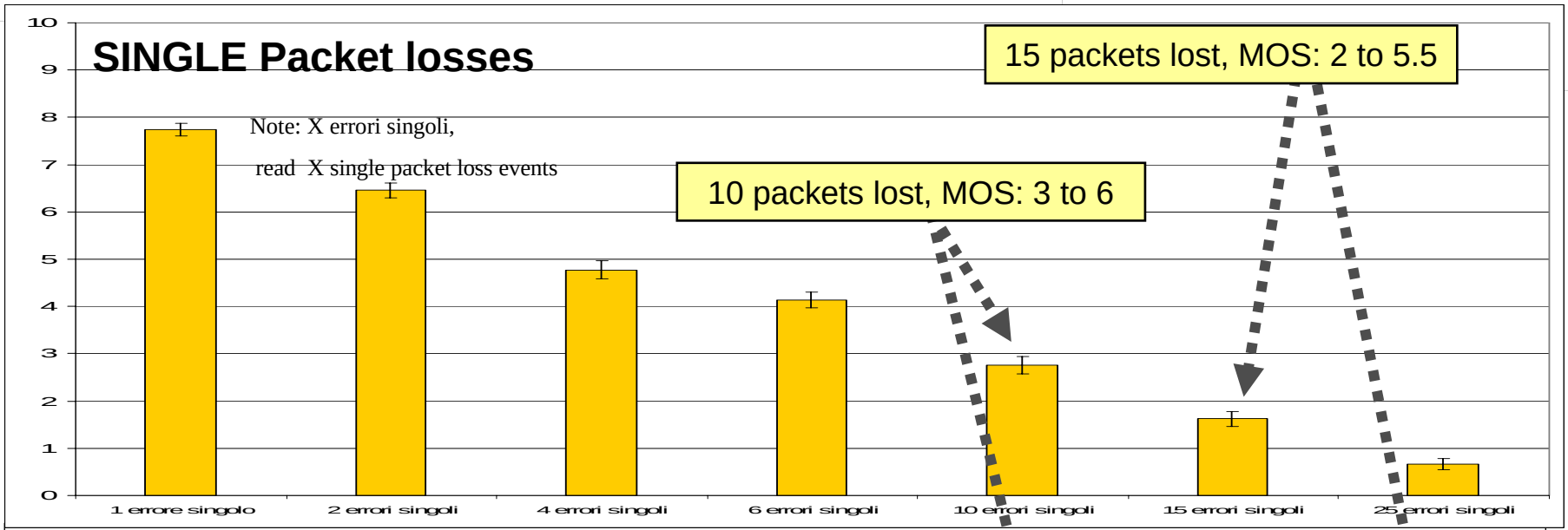
Typical target:	Loss distance:	1 per 30 minutes
	Loss period:	few IP packets
	Severe Loss distance:	1 per days/week
	Severe Loss period:	> TBD

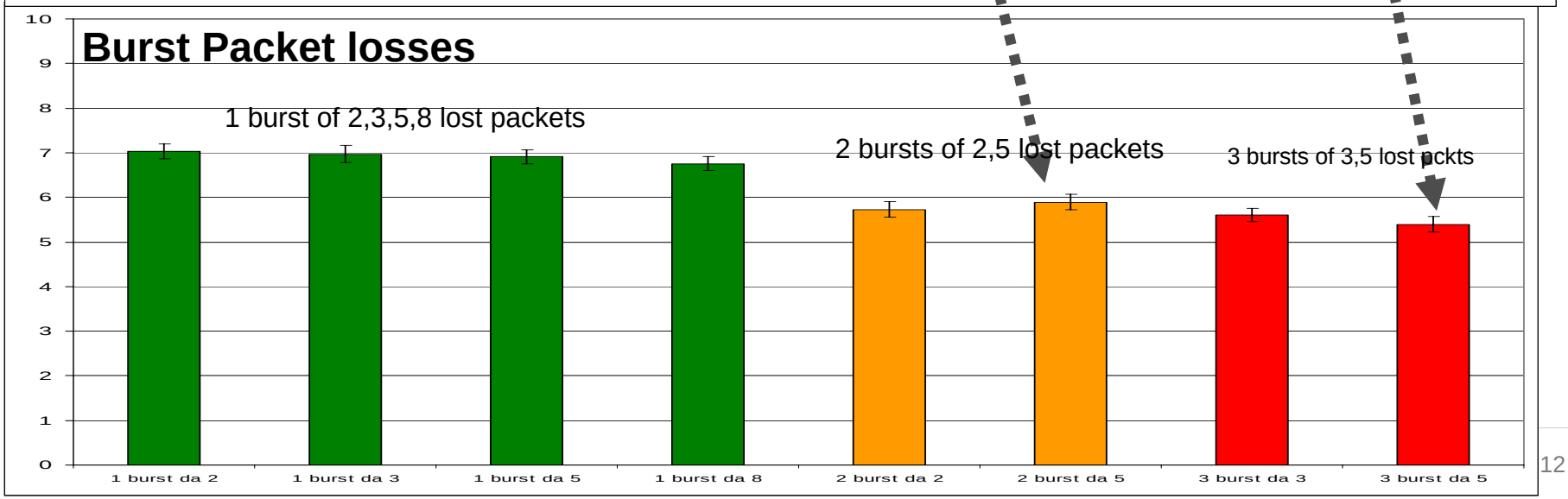
Note that the rate of error events is more impacting the user experience than the weight of a single event (at least for up to short errored events)

Input from Subject Video Quality Testing

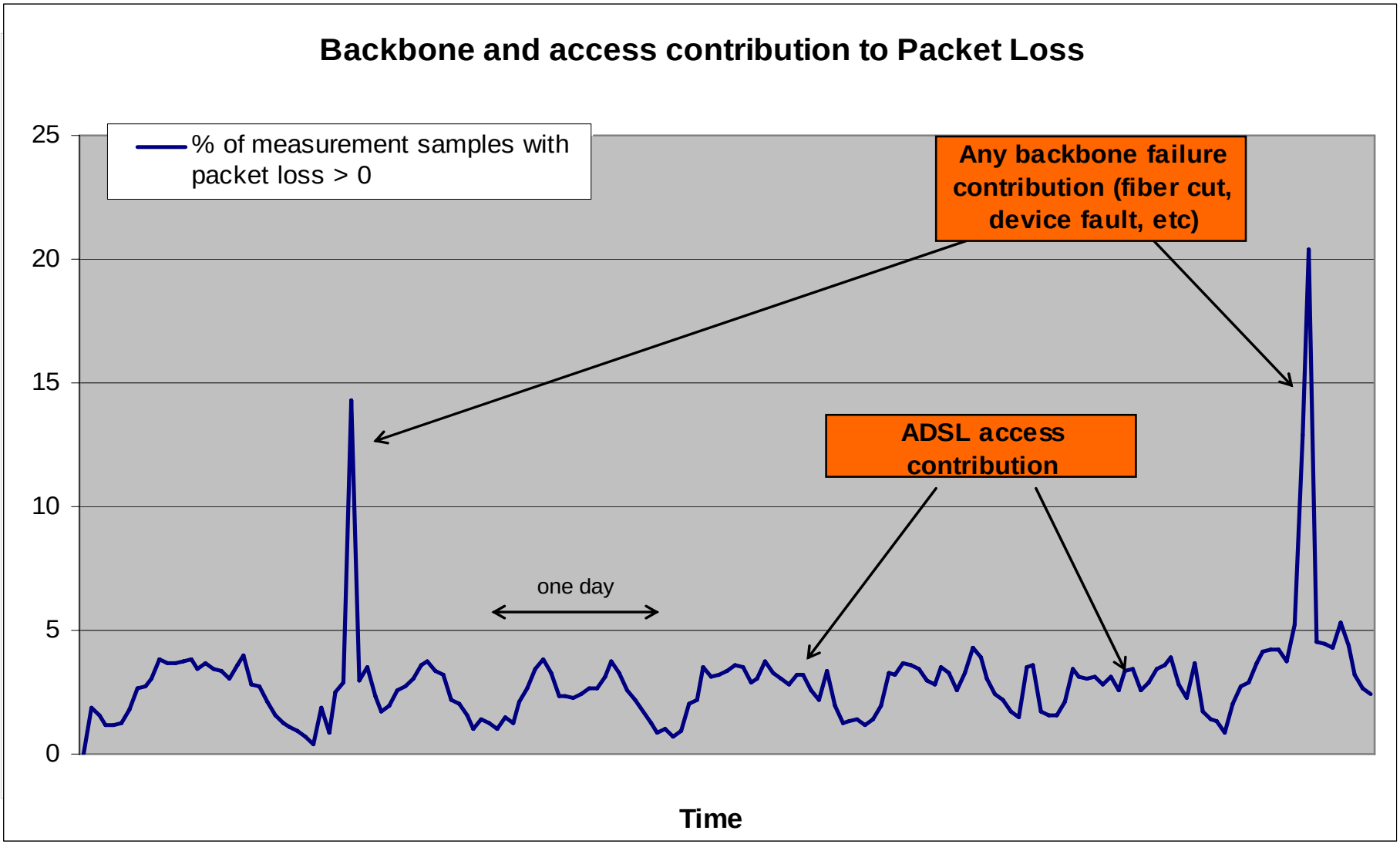
- Subjective Tests on IPTV SD Service
- One minute video sequences with sport (soccer) content
- Different packet loss profiles introduced (taking into account ADSL access loss profiles)
  - Single losses, burst losses, at different rates
- MPEG-2 4 Mbps streams
- Very likely that a single packet loss is perceived by the user:
  - On a separate ‘expert viewing’ analysis, only about 10% of single packet losses event didn’t produce any visible artifacts (out of few hundreds cases)
- STB used for the testing does perform some error concealment

Video subjective testing - results

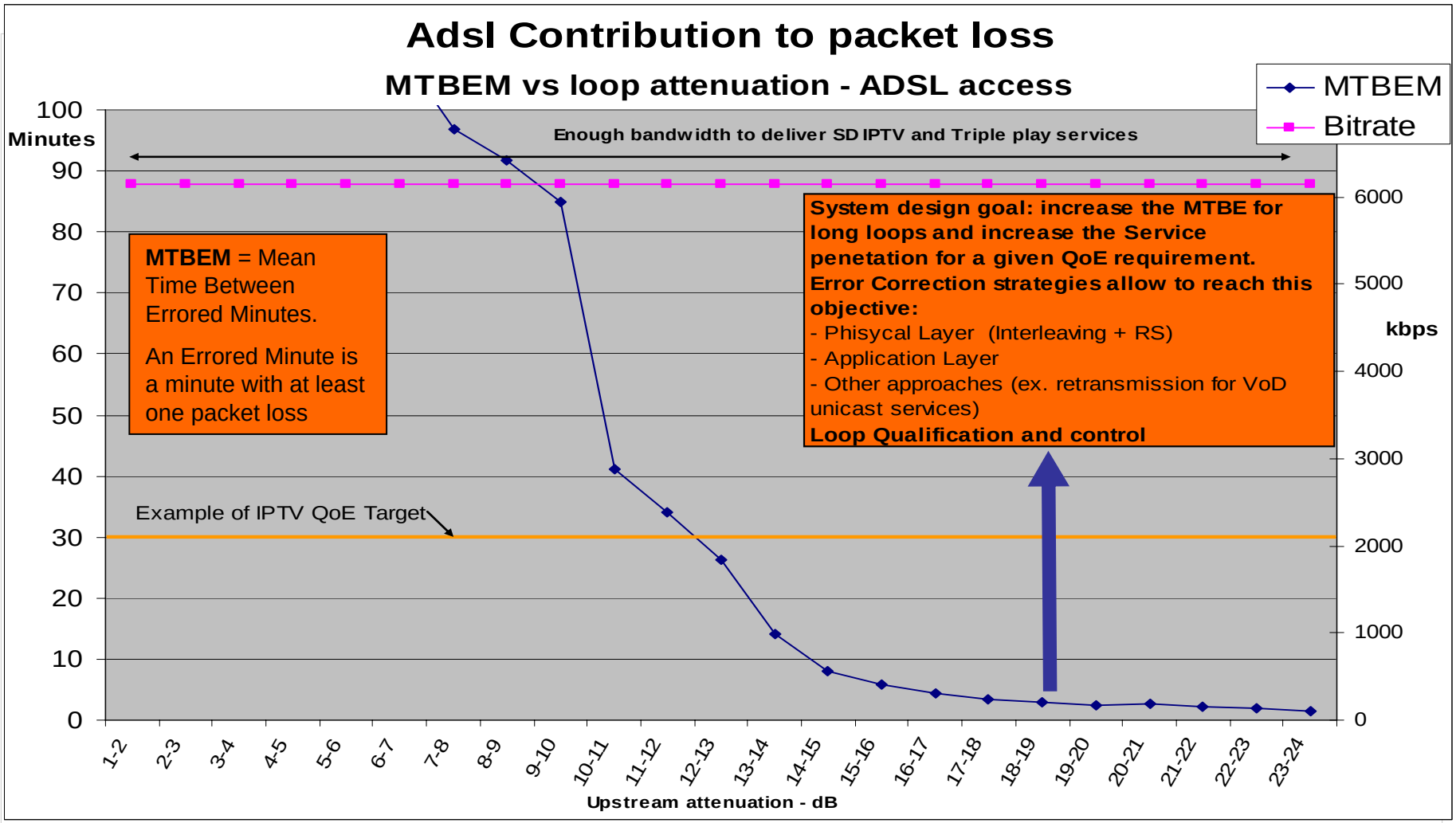




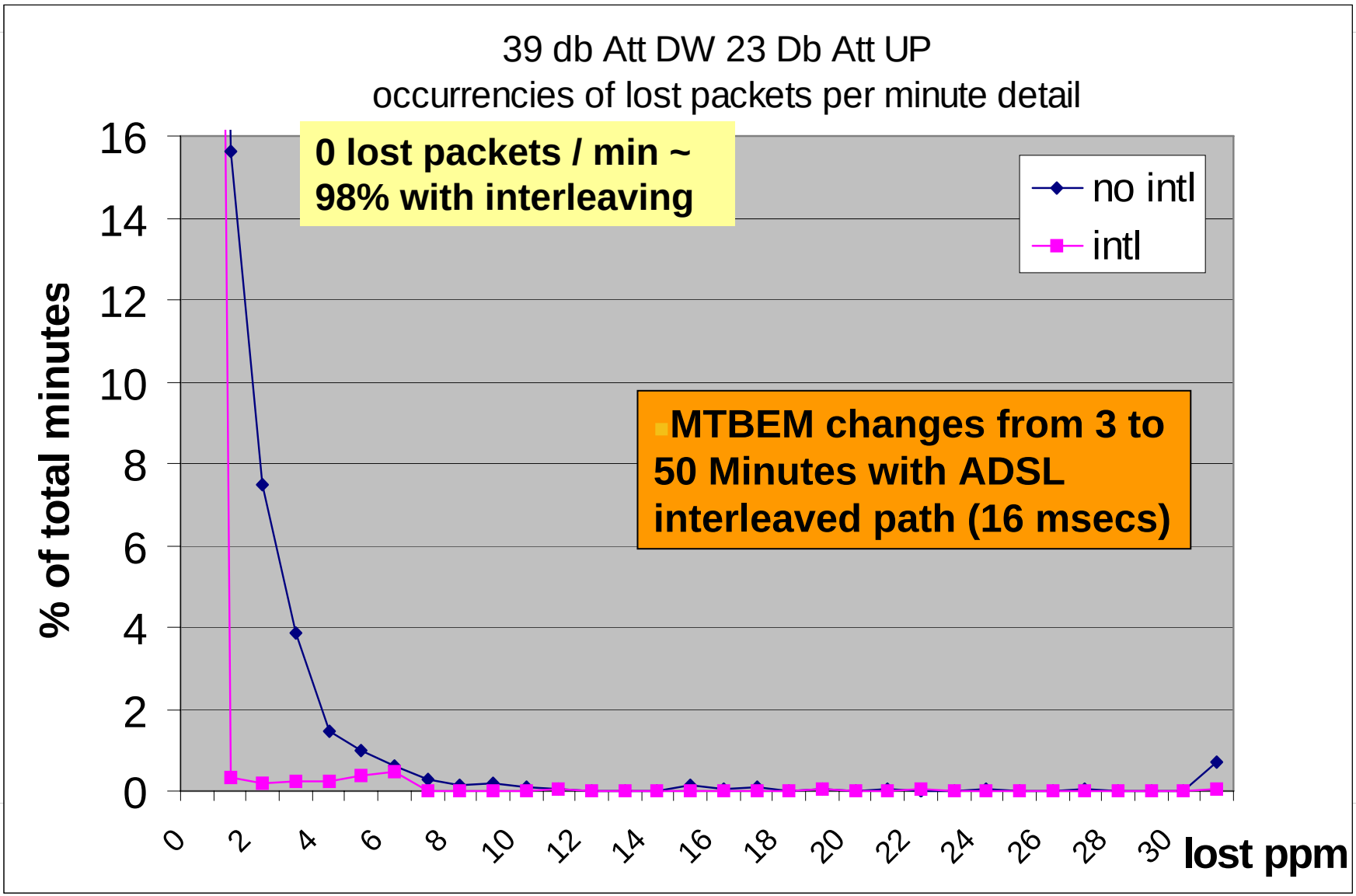
Backbone and Access contribution to Packet Loss
Aggregated View



Access contribution to Packet Loss
Loop length, QoE and Service penetration



Access contribution to Packet Loss
Single line with High attenuation
ADSL Error correction



Error recovery for IPTV

- Goal
  - Extending the reach of the IPTV service for ADSL/ADSL2+ access
  - Meet QoE requirement
- No current recognised Best Practice or solution wide spread in the industry
- Possible options:
  - DSL Physical Layer (Interleaving, RS, ADSL2/2+ improvements)
    - Multiple bearer channels capabilities from ADSL2+ standard
  - Application Layer FEC
    - MPEG CoP3, Other codes, (DVB IPI is evaluating different alternatives)
    - Need to be supported on the Service end points: Head end, STB
    - Currently no or limited availability in the industry
  - Possible use of both of a PHY Layer and Application Layer FEC
    - Care must be used: two non linear processes
  - Retransmission
    - Likely feasible for Unicast services

→ Measure and study carefully packet loss patterns in the network to choose the best approach, dimension the best error correction strategy and optimize investments

Some clues for network engineering to improve IPTV QoE

- Backbone
  - Redundancy
  - High Availability
  - Minimize routing convergence time
  - IP QoS-enabled to handle possible congestions
    - Note that for an IP triple play broadband operator might be challenging to always guarantee that every link will transport less than the 50% of its capacity (to avoid congestion in case of failure of a redundant link).
- Access
  - QoS in bottlenecks points:
    - At the Residential Gateway for upstream traffic
    - At the DSLAM and/or BRAS/BNG for downstream traffic
  - Error recovery design (might span across the whole network in case of an Application Layer error correction or retransmission)
  - DSL Line qualification and monitoring
- Understand user requirements, sometimes it is also useful to save money!
- Use in service, passive, end-to-end measurements to assess service performance
- DSL Forum WT-126 Provides QoE performance guidelines for IPTV services.

Thank you

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