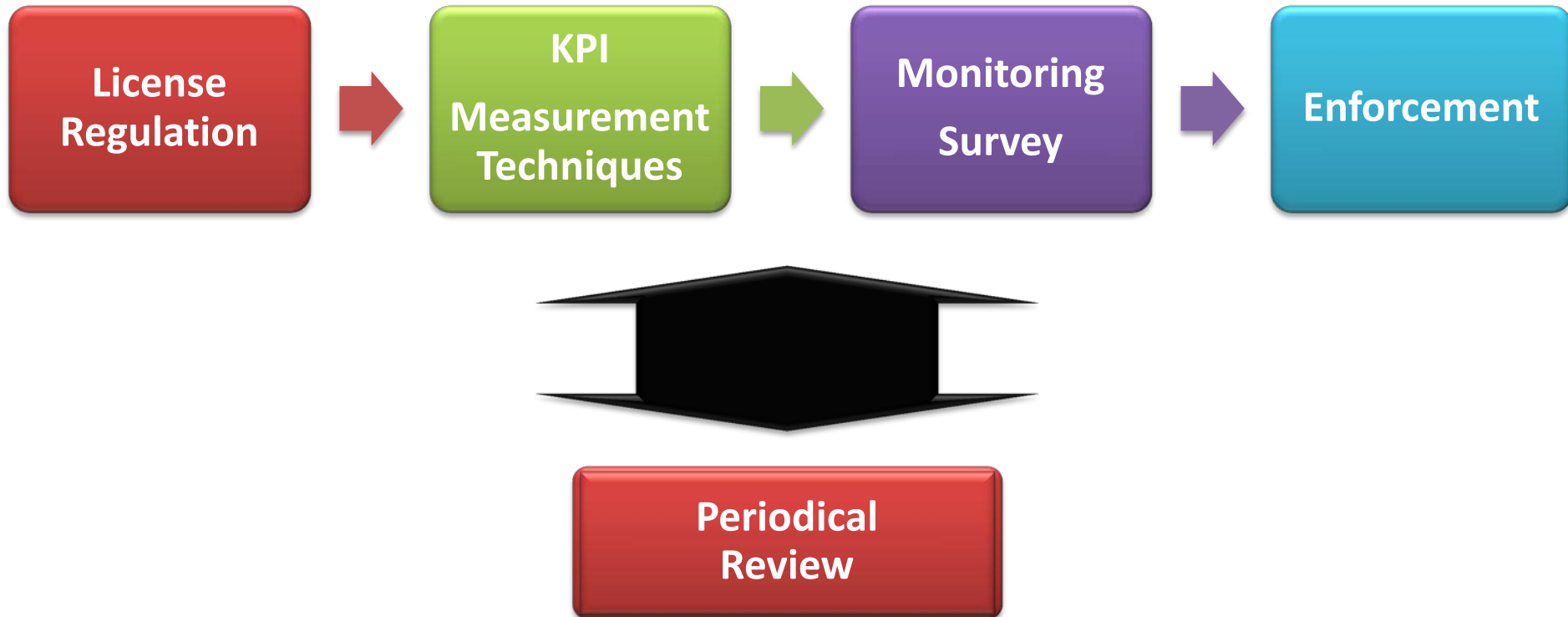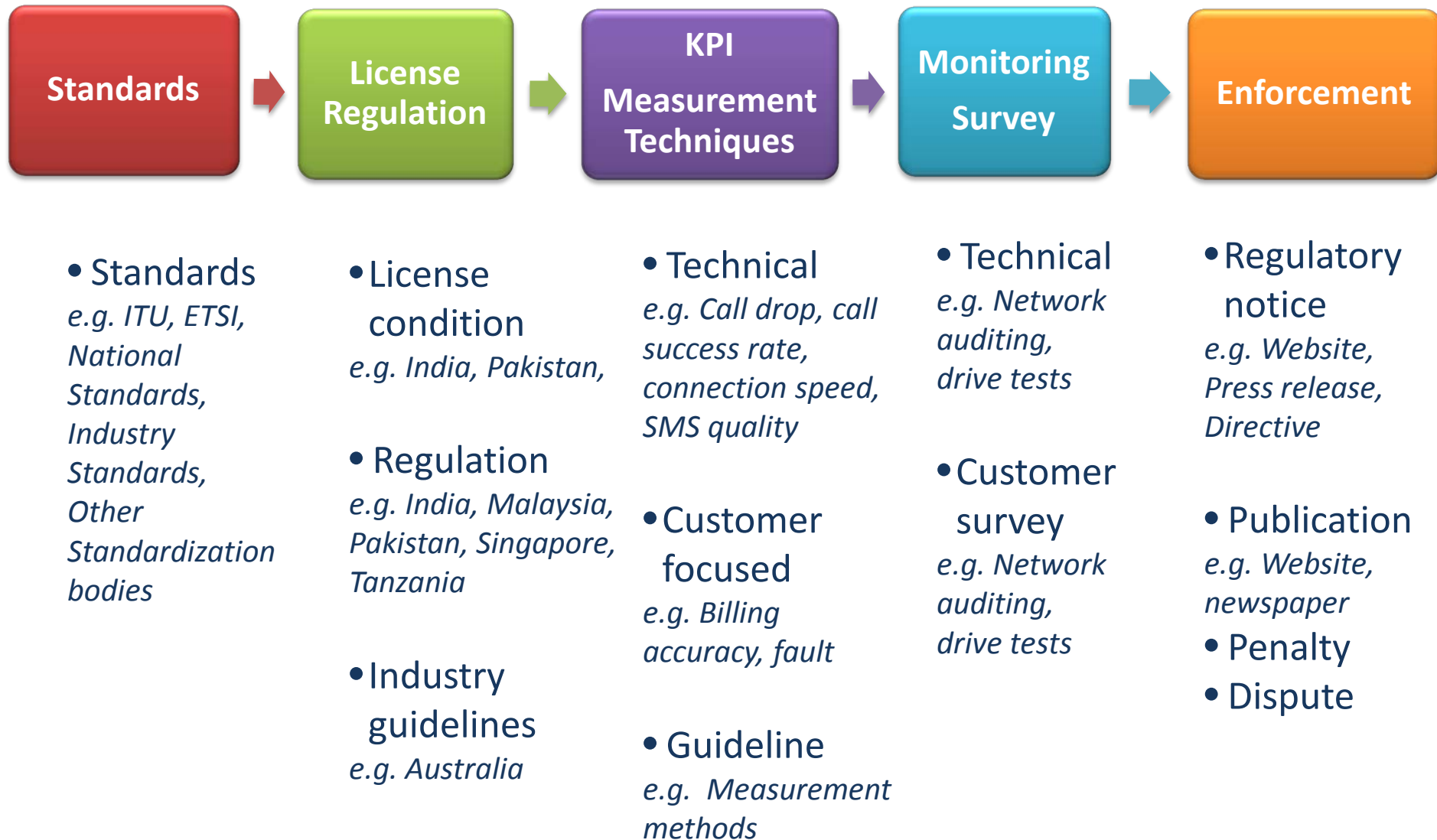# Session 4

Developing a Regulatory Framework for Quality of Service / Quality of Experience

Quality of Service Regulatory Framework

Quality of Service Regulatory Framework

Standards → **License Regulation** → **KPI Measurement Techniques** → **Monitoring Survey** → **Enforcement**

- Standards
  e.g. ITU, ETSI, National Standards, Industry Standards, Other Standardization bodies

- License condition
  e.g. India, Pakistan,

- Regulation
  e.g. India, Malaysia, Pakistan, Singapore, Tanzania

- Industry guidelines
  e.g. Australia

- Technical
  e.g. Call drop, call success rate, connection speed, SMS quality

- Customer focused
  e.g. Billing accuracy, fault

- Guideline
  e.g. Measurement methods

- Technical
  e.g. Network auditing, drive tests

- Customer survey
  e.g. Network auditing, drive tests

- Regulatory notice
  e.g. Website, Press release, Directive

- Publication
  e.g. Website, newspaper

- Penalty
- Dispute

Identification of QoS Criteria & Parameters

Use of QoS Parameters

QoS Level
- Specifying the level of quality of service in customer telecommunication service contracts or in the description of terms and conditions of the service

QoS Comparison
- Comparing the level of quality and quality commitments of services of different service providers

QoS Level Attributes
- Preparing long-term studies on the level of quality attributes of a specific service

QoS Report Publication
- Preparing statistics, reports and publications of the quality of a service.

QoS Minimum Level & Regulatory Compliance
- Regulatory purpose including specification of the minimum level of quality
- Monitoring of services by, for example, reports on a regular basis and statistics for specific situations

Source: ITU-T Recommendations E.802

Methodology for Identification of QoS Criteria and Parameters

| General Considerations | Identification of User's QoS criteria | Conversion of QoS Criteria to QoS Parameters | Publication of QoS Parameters |

| Measurements | Guidelines for defining QoS Objectives | Verification of QoS Objectives |

Please read ITU-T Rec. 802 for details and examples

General Aspects of Quality of Service Parameters

QoS Parameters
- To be considered on a service-by-service basis
- To be specified in terms understandable to the customers

QoS Criteria
- To be specified on an end-to-end basis, at which the user's terminals are connected
- To be specified in terms understandable to the customers
- To be specified in more technical terms for use within the industry

QoS Priority
- Customer may require different order of priority for various performance parameter
- QoS profile of a customer segment may vary with time and it is essential for the service provider to ascertain the customer's changing requirements

Source: ITU-T Recommendations E.802

Choosing Quality of Service Parameters

Purpose
- The precise purpose for which the parameters will be used

Expectation
- The quality and performance as expected by the users of state-of-the-art technology

Relevance & Usefulness
- The usefulness and relevance of the parameters from the users' perspective.

Reliability
- The degree to which the parameters will provide a reliable comparison of performance.

Cost & Resources
- The cost and resources needed in order to measure and report each parameter.

Source: ITU-T Recommendations E.802

Identification of User's QoS Criteria : Three Models

Universal Model

	Quality Components and Criteria			
	Performance Criteria	Aesthetic Criteria	Presentational Aspects	Ethical Aspects
Functional Elements				

1. ...
2. ...
3. ...
   ...
   ...
   ...
n. ...				

Please read ITU-T Rec. 802 for details of these models

Identification of User's QoS Criteria : Three Models
Performance Model

	Service Quality Criteria						
	Speed 1	Accuracy 2	Availability 3	Reliability 4	Security 5	Simplicity 6	Flexibility 7
Service Function							
Service Management — Sales & Pre Contract Activities 1							
Provision 2							
Alteration 3							
Service Support 4							
Repair 5							
Cessation 6							
Connection Quality — Connection Establishment 7							
Information Transfer 8							
Connection Release 9							
Billing 10							
Network / Service Management by Customer 11							

Identification of User's QoS Criteria : Three Models

Four-Market Model

Customer

Components of Service Creation and Delivery

| Customer's Equipment | Service Transport | Service Provision | Content Creation |

Customer Perception of Quality

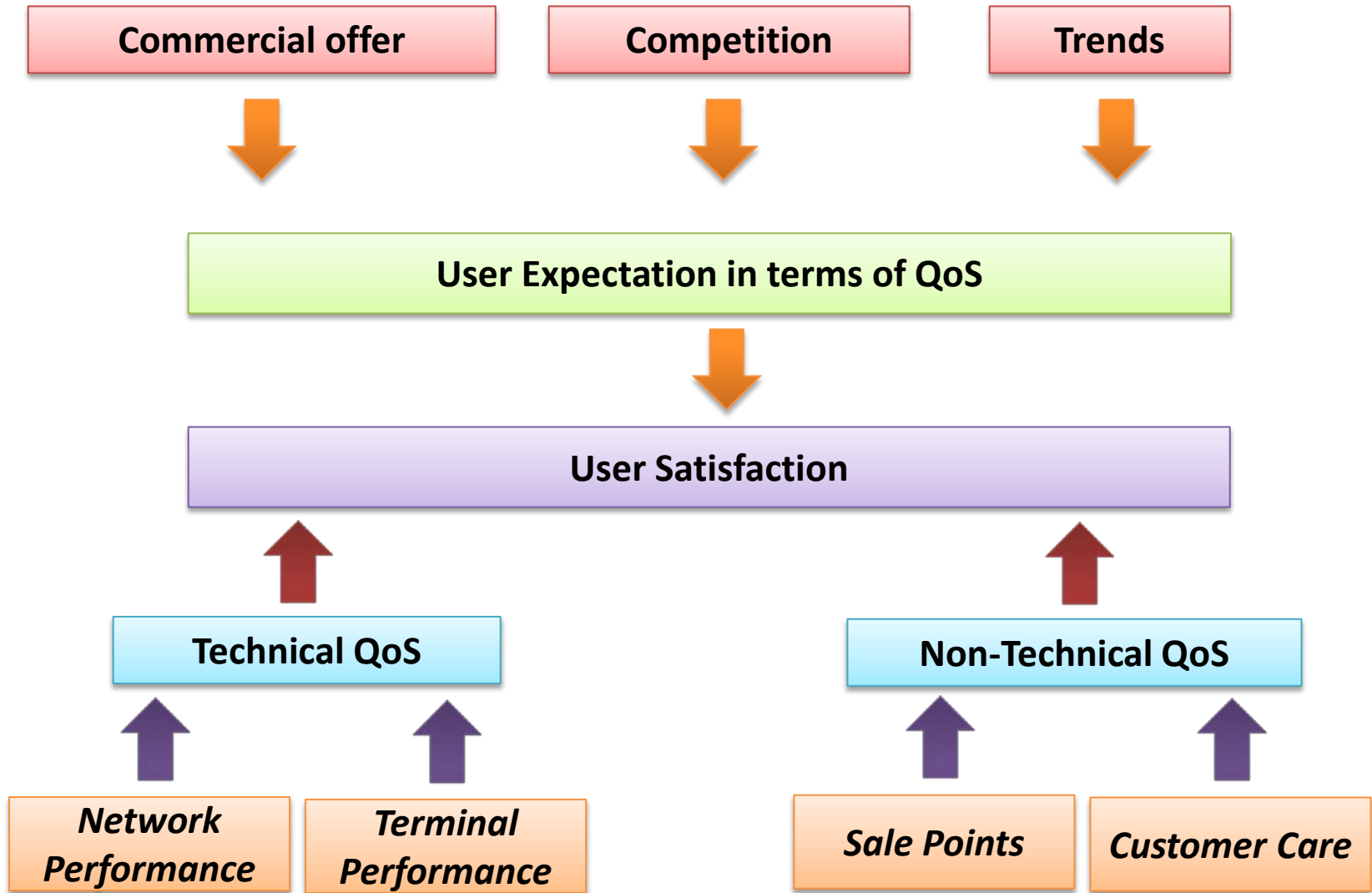*Please read ITU-T Rec. 802 for details of these models*
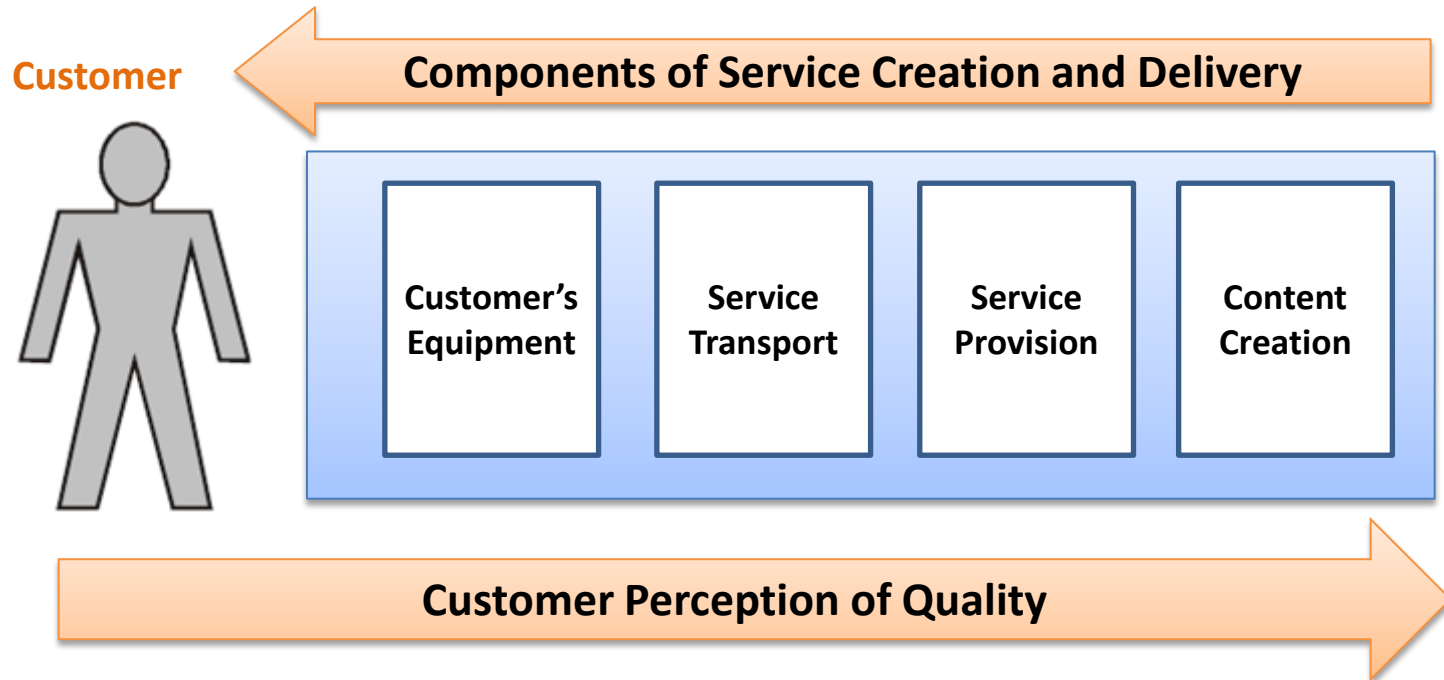
Measurements

- **Objective measurements**
  - *Intrusive measurements*
  - *Non-Intrusive*
  - *Use of models*
  - *Monitoring and analysis of signaling information*

- **Subjective measurements**

- **Who should perform the measurements?**
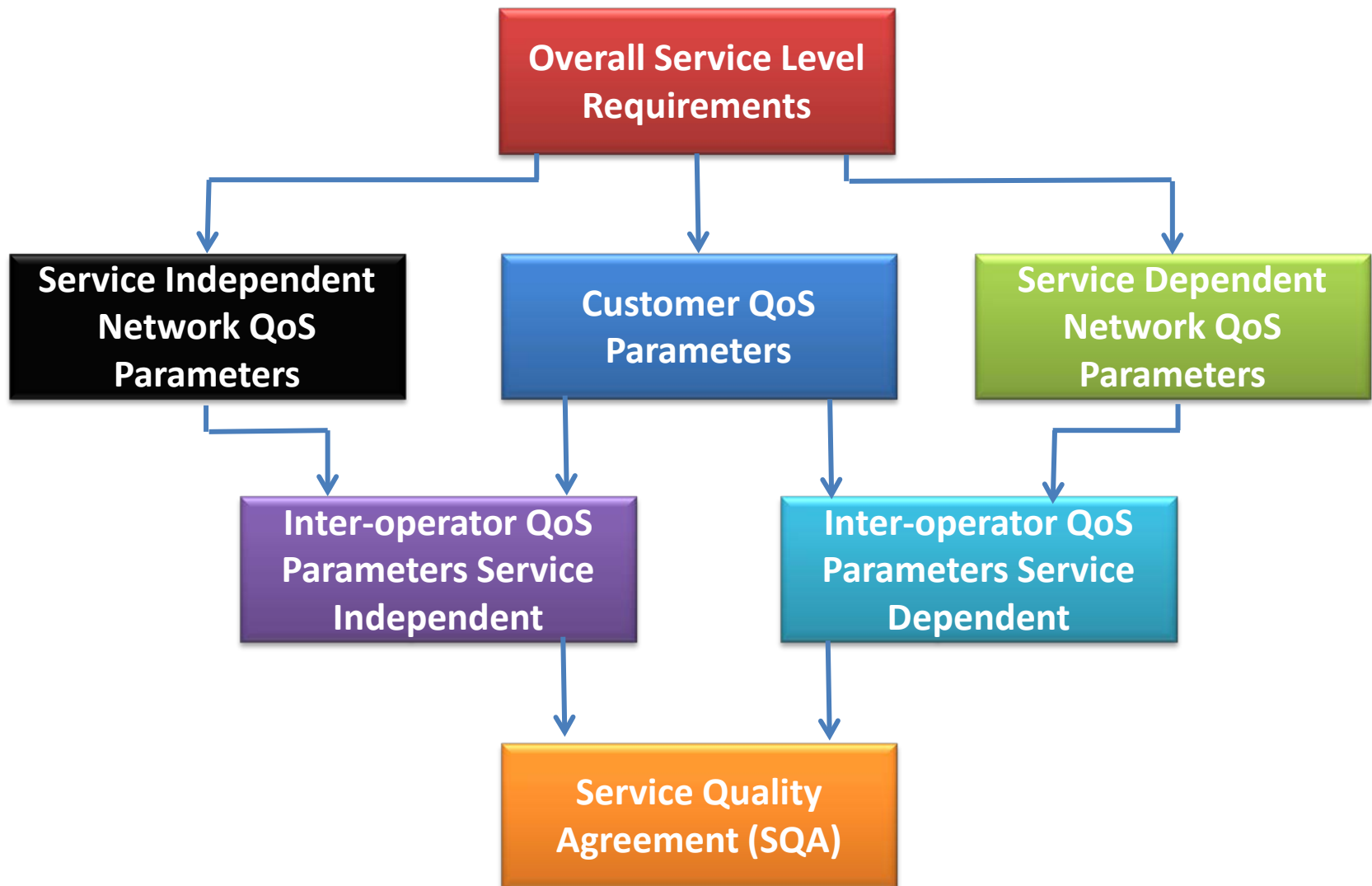
Defining quality objectives

Used to determine minimum and maximum performance limits and the desired (optimum) performance level of QoS parameters

- **Defining initial quality objectives**

- **Defining target values**

- **Tuning quality objectives**

Quality of Service & User Satisfaction

Commercial offer	Competition	Trends

User Expectation in terms of QoS

User Satisfaction

Technical QoS	Non-Technical QoS

Network Performance	*Terminal Performance*	*Sale Points*	*Customer Care*

Service Level Agreement (SLA) and QoS Parameter

Determination of QoS Parameters

QoS Parameters

Potential QoS Parameters Classified under Categories

Preliminary information on ICT services	Contractual matters between ICT service providers and customers	Provision of services	Service alteration
Technical upgrade of ICT services	Complaint management	Commercial support provided by service provider	Technical support provided by service provider
Documentation of services (operational instructions)	Cessation of service	Network/Service management by customer	Charging and billing
	Repair services		

For details of QoS parameters that have been identified as being potentially useful for comparison of SPs' performance levels , please read ITU-T Recommendations E.803

QoS Aspects and the Corresponding QoS Parameters for Mobile
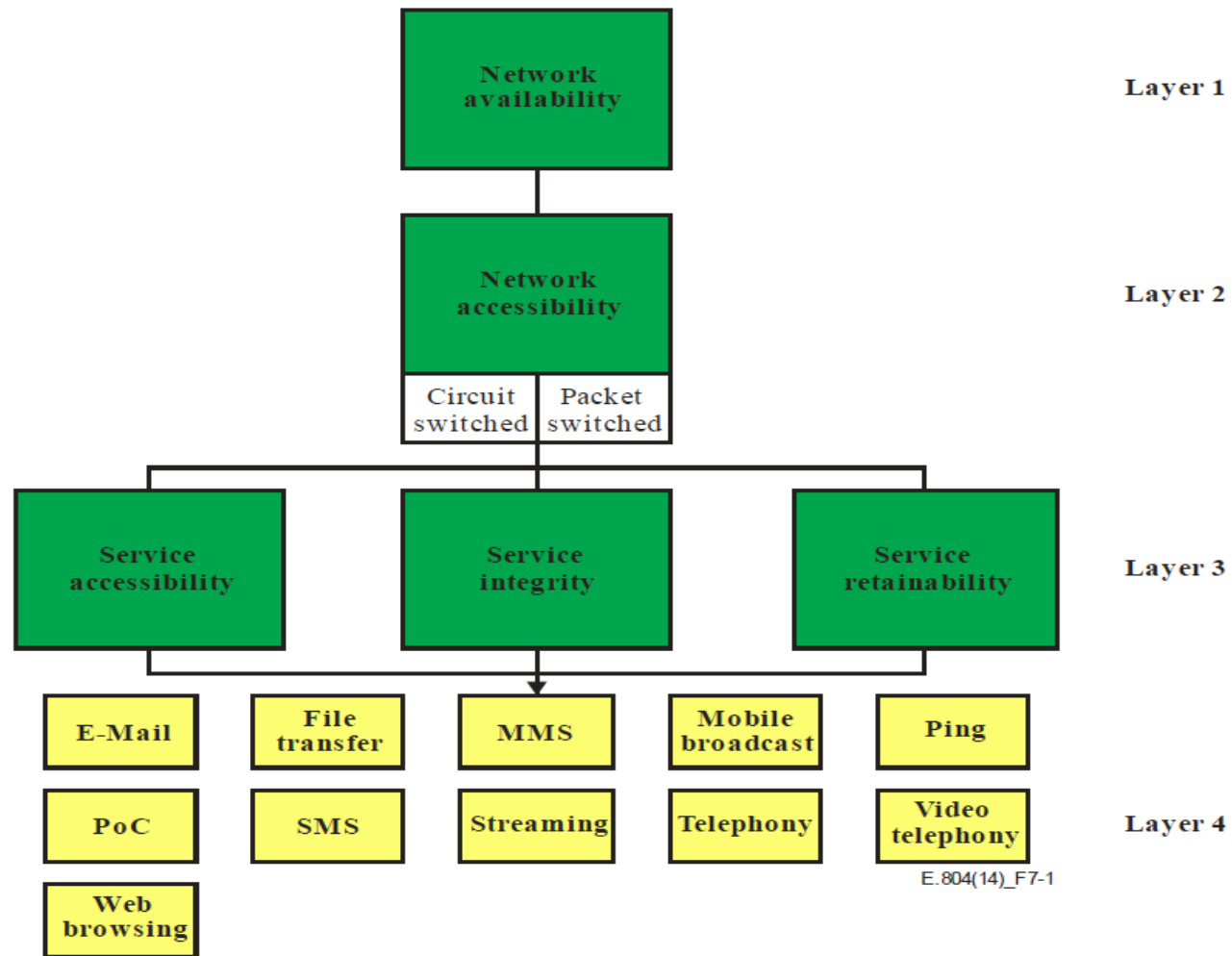
For details of parameters and measurements, please read ITU-T Recommendations E.804 "QoS aspects for popular services in mobile networks"

ITU-T Recommendations and QoS / QoE

|	ITU-T Recommendations
Subjective assessment of voice quality	P.85, P.800, P.805, P.806, P.810, P.830, P.835, P.840, P.851, P.880, P Suppl. 24, P Suppl. 25
Objective assessment of voice quality	P.862, P.862.1, P.862.2, P.862.3, P.863, P.863.1
QoS and QoE for multimedia and assessment methods	G.1010, G.1011, G.1030, G.1040, G.1040, G.1050, G.1070, G.1080, G.1081, G.1082, P.1010, Y.1562, P.1201, P.1201.1, P.1201.2, P.1202, P.1202.1, P.1202.2, P.1501
telephonometry	P.32, P.48, P.50, P.51, P.52, P.57, P.58, P.59, P.61, P.64, P.75, P.76, P.78, P.79, P.300, P.310, P.311, P.313, P.330, P.340, P.341, P.342, P.350, P.360, P.370, P.380, P.581, P.501, P.502, P.505, P Suppl. 10, P Suppl. 16, P Suppl 20,
Hands free Communications and User Interfaces in Vehicles	P.1100, P.1110
Network Performance and OAM for Performance Measurement	Y.1540, Y.1541, Y.1543, Y.1544, Y.1560, Y.1561, Y.1563, Y.1564, Y.1565. G.8013/Y.1731, G.8113.1, and G.8113.2
QOS FOR MOBILE SERVICES	E.804
TRAFFIC MANAGEMENT	Y.1221, Y.1222, Y.1223, Y.1530, Y.1531, Y.1542
BITRATE MEASUREMENT OF INTERNET CONNECTIONS	currently available as working draft under Question 15/11

QoS Technical KPIs

Understanding Key Technical Parameters

|	
IP Packet Error Ratio (IPER) *[Source ITU-T Rec. Y.1540]*	IP packet error ratio is the ratio of total errored IP packet outcomes to the total of successful IP packet transfer outcomes plus errored IP packet outcomes in a population of interest.
IP Packet Transfer Delay (IPTD) *[Source ITU-T Rec. Y.1540]*	IP packet transfer delay is defined for all successful and errored packet outcomes across a basic section or an NSE (network Section Ensemble).
Round-Trip Time (ms)	Time taken for a packet to reach the destination and return. This is significant in systems that require two-way interactive communication such as online commerce and gaming.
IP Delay Variation (IPDV) *[Source: ITU-T Y.1545 (05/2013)]*	IP packet delay variation (IPDV) [ITU-T Y.1540]: The difference between the actual IPTD of a packet and a reference IPTD for a packet population of interest. IPDV is also referred to as "jitter", and is usually reported in milliseconds.
IP Packet Loss Ratio *[Source: ITU-T K.88 (11/2011)]*	The ratio of total lost IP packet outcomes to total transmitted IP packets in a population of interest.
Availability *[Source ITU-T Rec. E.802]*	Availability of an item to be in a state to perform a required function at a given instant of time or at any instant of time within a given time interval, assuming that the external resources, if required, are provided.

Packet Loss and Delay Requirements

Source: ITU-T Recommendations G.1010

Error Tolerance
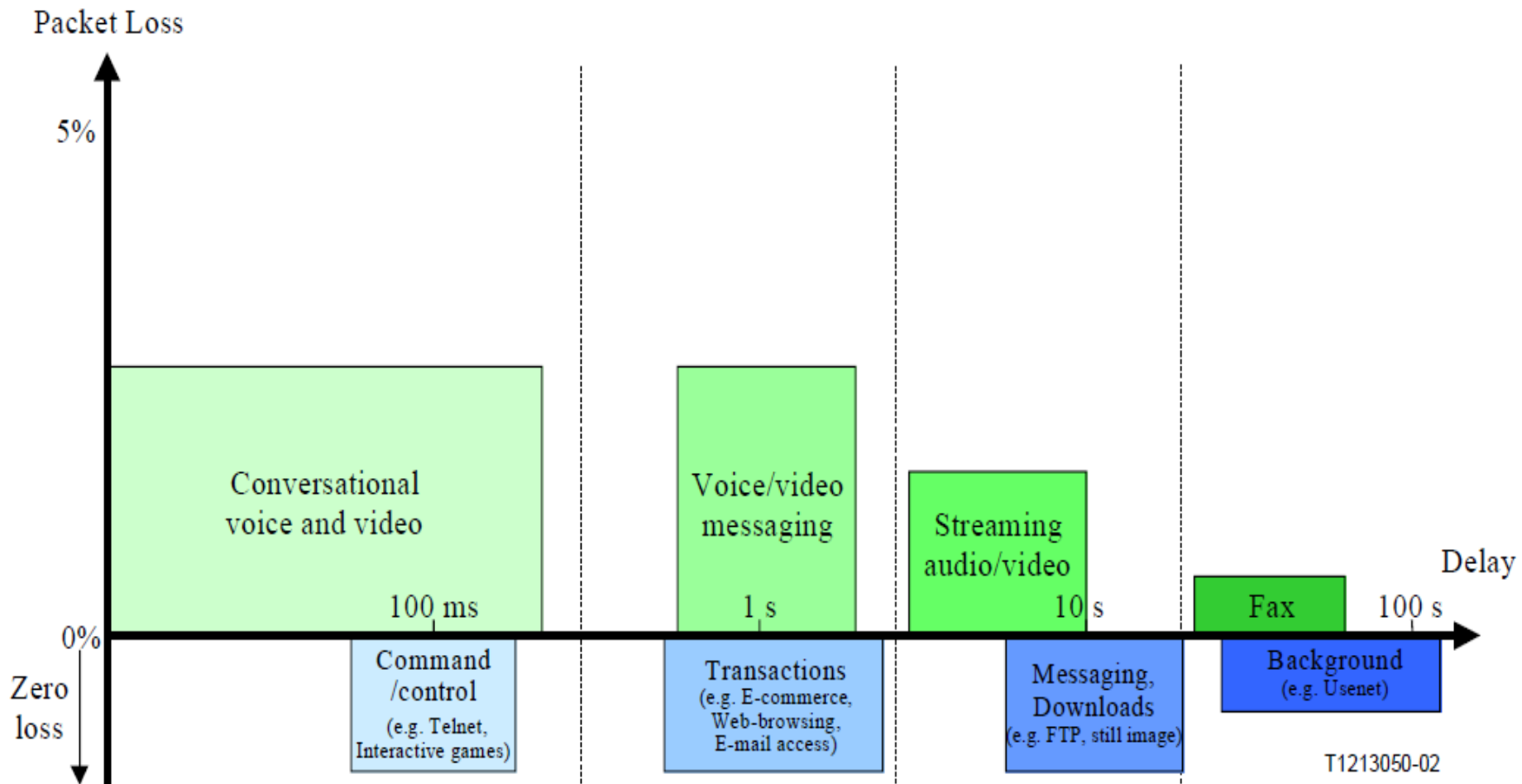
	Interactive (delay <<1 s)	Responsive (delay ~2 s)	Timely (delay ~10 s)	Non-critical (delay >>10 s)
Error tolerant	Conversational voice and video	Voice/video messaging	Streaming audio and video	Fax
Error intolerant	Command/control (e.g. Telnet, interactive games)	Transactions (e.g. E-commerce, WWW browsing, Email access)	Messaging, Downloads (e.g. FTP, still image)	Background (e.g. Usenet)

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Source: ITU-T Recommendations G.1010

Applications & QoS Requirement
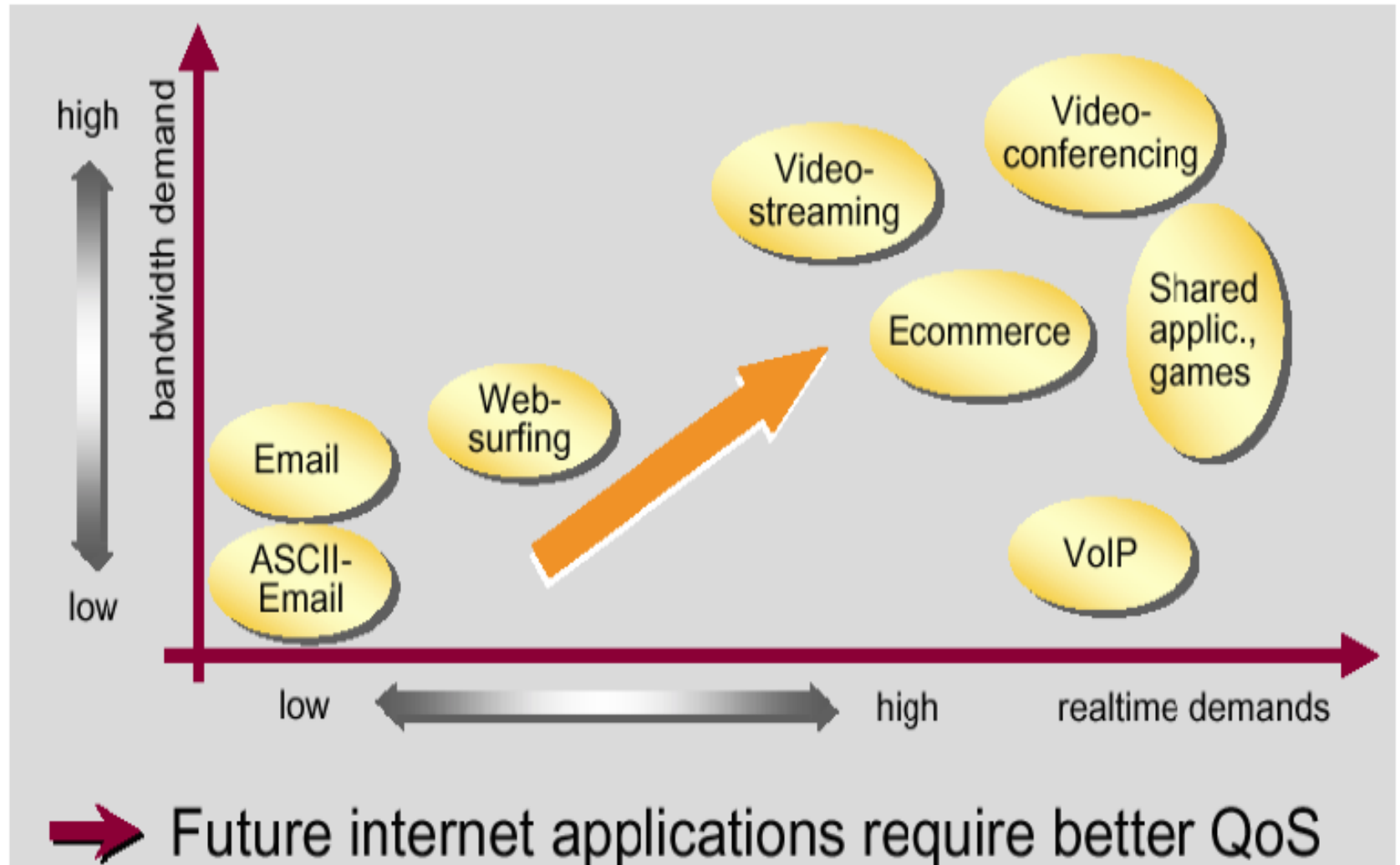
Example Services for IP QoS Classes (Y.1541)

QoS Class	Example Applications	Node Mechanisms	Network Techniques
0	Real-Time, Jitter sensitive, high interaction (Speech, Video Transfer)	Separate Queue with preferential servicing, Traffic grooming	Constrained Routing and Distance
1	Real-Time, Jitter sensitive, interactive (Speech, Video Transfer)		Less constrained Routing and Distances
2	Transaction Data, Highly Interactive, (Signaling)	Separate Queue, Drop priority	Constrained Routing and Distance
3	Transaction Data, Interactive		Less constrained Routing and Distances
4	Low Loss Only (Short Transactions, Bulk Data, Video Streaming)	Long Queue, Drop priority	Any route/path
5	Traditional Applications of Default IP Networks	Separate Queue (lowest priority)	Any route/path

Source: ITU-T Recommendations Y.1541

QoS Non-Technical KPIs

Non-Technical Parameters

```
┌──────────────┐      ┌──────────────┐
│   Service    │ ───▶ │ Fault Repair │
│  Activation  │      │     Time     │
│     Time     │      │              │
└──────────────┘      └──────────────┘
                              │
                              ▼
┌──────────────┐      ┌──────────────┐
│ Bill Correctness│◀─ │  Complaint   │
│   Compliant  │      │  Resolution  │
│              │      │     Time     │
└──────────────┘      └──────────────┘
        │
        ▼
┌──────────────┐
│  Assistance  │
│ Provisioning │
│     Time     │
└──────────────┘
```
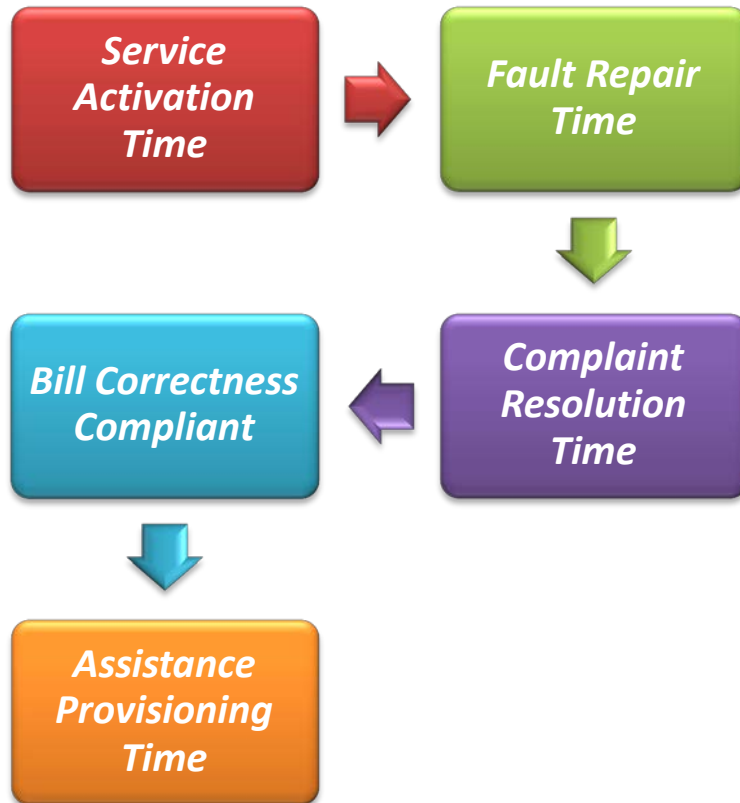
- **CUSTOMER SATISFACTION**
  - Service quality
  - Service availability
- **PROVISION OF SERVICE**
  - Service activation / de-activation / restoration time
  - If target value is not reached, further analysis might be necessary
- **NETWORK AVAILABILITY**
  - MDT (Mean Down Time)
  - MTTF (Mean Time To Failure)
  - MTBF (Mean Time Between Failures)
- **BILLING INFORMATION**
  - Clarity of tariff plans
  - Ease of switching between plans
  - Ease of getting billing information
  - Ease of bill payments Ease of bill payments
  - Ease of getting refunds
  - Billing accuracy

Quality of Service Testing

Performance Measurement - ITU Recommendations

G.1011
- Provides a reference guide to existing standards for quality of experience (QoE) assessment methodologies

G.1030
- Provides a framework of tools to obtain IP network performance, estimate the performance of user applications, and apply perceptual models to gauge user satisfaction with the end-to-end performance

G.1050
- Describes an IP network model that can be used for evaluating the performance of IP streams

P.1501
- Describes the method and procedures for subjective testing of user perceived quality of web browsing

Several Methods for evaluating the QoS of operators

QoS Classic approach

Drive Test → Assessing the coverage, capacity and Quality of Service (QoS) of a mobile radio network Benchmarking, Network optimization and Troubleshooting, Fine-tuning Network parameters for newly deployed sites.

End to End Measurement → Qualifying a given service from the access point through to PSTN from an end users perspective. QoE, Interoperability between mobile operators, benchmarking.

End user Surveys → Aimed at assessing the end-user's perception and acceptance of services. QoE, Benchmarking.

Churn – Rate Monitoring → Determine the degree of satisfaction or dissatisfaction of a user of a service. QoE, Check on Customer support reactivity.

Passive Testing

Passive Testing
- *Sniffs traffic (user data) as it is routed through a device;*
- *Performs analysis based on monitoring network traffic between two destinations*

Pros
- *The probe only needs 1 connection point to the network which mean less hardware*
- *Does not 'take over' the line under test so is never an inconvenience to end users*

Cons
- *Unknown traffic type makes it difficult to test maximum line capability*
- *Difficult to average different tests as the data traffic is not consistent*

Active Testing

Active Testing

- *Performs analysis based on sending traffic (probing packets) between two destinations*
- *Probing packets are injected in the network connection in order to measure the quality of service (QoS) of different services **(web browsing, file transfer, VoIP, etc)** over Internet connections*

Pros

- *The data (probing packets) is originated from a controlled source with predefined settings and therefore types of services can be fully controlled*
- *Easy benchmarking / comparison between measurements obtained from different internet connections provided by different ISPs*

Cons

- *Requires that the line under test be fully available*
- *Test design must be sure the line is idle before testing*
- *Requires both sending & receiving probes (monitoring tools)*
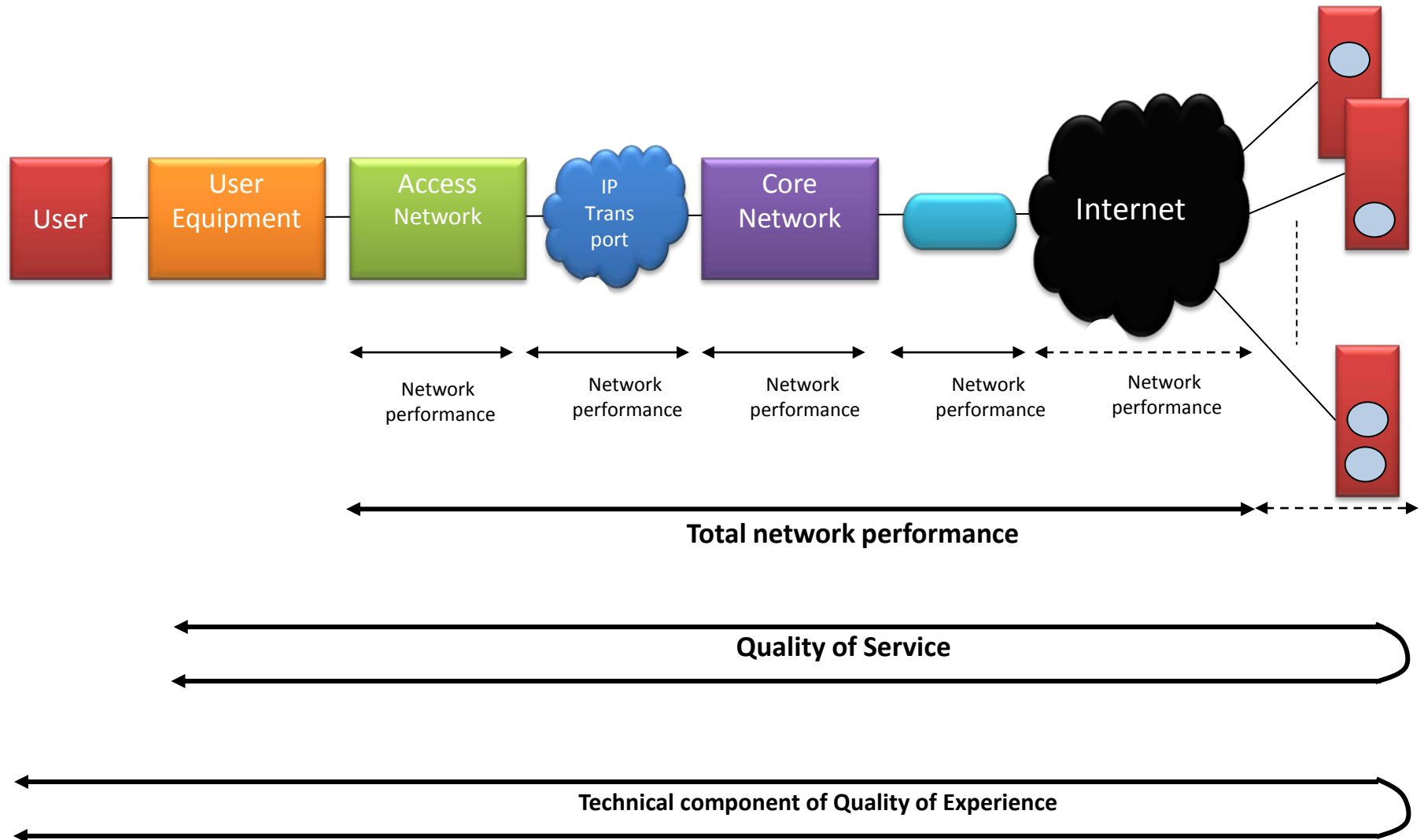- *Cost implications*

International Practices

- "**Active Testing**" is mostly adopted methodology by Regulators, in order to measure the QoS of Broadband Internet provided by ISPs

- Active Testing allows Regulators to produce a benchmarking report regularly

- **Example**

- OFCOM publishes research report on Fixed Line Broadband Performance in UK

- **Method** For data collection, a number of hardware monitoring tools (probes) has been distributed to the selected panellists. Download/Upload speed, packet loss, DNS resolution time, DNS failure ratio, jitter QoS parameters have been assessed
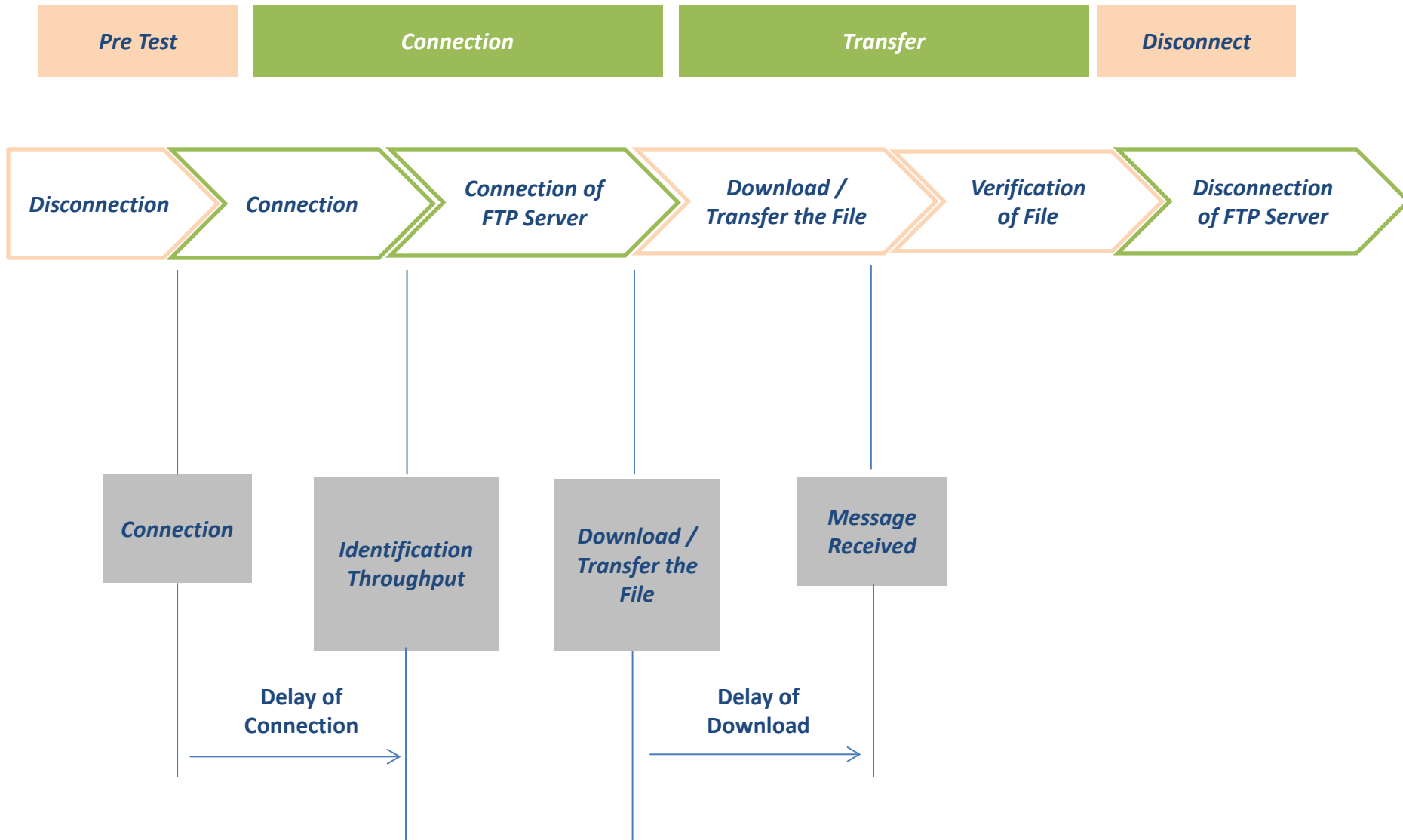
Challenges

- Active Testing methodology has some implementation challenges like:
    - The cost of implementing this methodology is quite high.

    - For benchmarking/ comparison of QoS performance of various ISPs, the sampling methodology is very critical QoS monitoring tools (probes) have to be deployed in a manner to replicate a "like to like" or "apple to apple" QoS performance comparison of ISPs

    - It requires as well a very close collaboration with ISPs and internet consumers

QoS / QoE - Data

User — User Equipment — Access Network — IP Transport — Core Network — Internet

Network performance | Network performance | Network performance | Network performance | Network performance

Total network performance

Quality of Service

Technical component of Quality of Experience

Test: Evaluation of QoS

- *Quality of Service – Data (FTP)*

Pre Test	Connection	Transfer	Disconnect

Disconnection	Connection	Connection of FTP Server	Download / Transfer the File	Verification of File	Disconnection of FTP Server

Connection	Identification Throughput	Download / Transfer the File	Message Received

Delay of Connection

Delay of Download

Points Worth Remembering in Test Methodology

- Should be User-Centric

Testing Time

- Test days: Weekdays or full week

- Test hours: Peak Hours & Off Peak Hours , focus on morning and night busy hours

- Saturdays - Sunday: testing or No testing

Test Locations / Devices

- Commercial state of the art devices used for capturing best available end-user quality

- Devices sourced from retail stores and SIM cards etc. from operator stores

- Test locations chosen independently by Regulator / Operator in blind test fashion

- Tests conducted in stationary as well as in moving state inside car / building

Points Worth Remembering in Test Methodology ….

- QoS Measurement Campaign prerequisites:
    - Specify Locations (e.g.: City, sector)
    - Prepare maps for those locations
    - Calculate Samples (attempts) required for each location based on population: For more information, please refer to ITU-T Recommendation E.804.
    - Calculate number of days/ hours required
    - Calculate number of hotspots (for measurement of data services) and locate those hotspots
    - Prepare a script for each service (e.g: Voice, FTP, HTTP…)
    - For Voice service measurement, specify the Mode (e.g: GSM, 3G or Dual mode)

Regulatory Framework for Quality of Service

- Requirements so as to enforce the quality of service:

  - ICT Law: Adopted and published in the Official Gazette

  - Regulations / Guidelines on Quality of Service:
    - **With a purpose:**
      - Improve / maintain service quality;
      - make QoS Information available to customers;
      - assist the development of telecommunication markets and;
      - improve operation and performance of interconnected networks.

    - **Guidance about:**
      - Methodologies for measuring, reporting and recording.
      - QoS parameters definitions and thresholds.

    - **Enforcement mechanism**

Performance Reporting

- The NSP should report the performance values periodically as may be required to the regulatory authority and performance values by the interconnected NSPs

- The NSP should retain quality of service data, including all measurements and related records, for a minimum of twelve (12) months after the end of the "reporting period".

- When the performance measurement of a network section exceeds an agreed threshold value for a parameter, the NSP should report the incident to its interconnected NSP and regulatory authority

Enforcement Mechanism of Quality of Service …

- Reports of QoS submitted Monthly or Quarterly by Telecom Operators to the Regulatory Authority:
  - Include technical and non technical parameters

- QoS Monitoring tools for auditing the QoS of mobile networks independently

- Penalties and Disincentives

- Independent customer survey and their publication

Quality of Service Regulation

- QoS Regulation is part of customer protection;
- Main purposes of QoS regulation are [ITU-T Supp. 9 of E.800 Series]:
    - Helping customers be aware of the Quality of service provided by Telecom Operators/ ISPs through networks (mobile & fixed), so that to make their own choices;
    - Checking claims by operators;
    - Understanding the state of the market;
    - Maintaining / improving the QoS in presence of competition;
    - Maintaining / improving the QoS in absence of competition;
    - Helping operators to achieve fair competition; and
    - Making interconnected networks work well together.

Audit of Quality of Service

- Purpose of QoS Auditing :
  - Verify the QoS of Mobile Networks experienced by customers and
  - Compare the Results (from audit exercise) against the license obligations

- Methods to audit telecom operators' are, but not limited to:
  - Drive Test (performed on quarterly basis or any time required)
  - Consumer survey
  - Data submitted on monthly or quarterly basis by Telecom Operators Etc.

QoS Consumer Surveys

- Another method of measuring quality of service is performing consumer surveys.

- This method can effectively pinpoint the weakest elements of service quality, giving operators great feedback, while allowing customers to compare opinions about various operators with other people.

- It is also a great addition to the indicator-based method of measurement. Contrasting those two sets of data can determine whether a weakness identified by consumers also falls among the low-levels of relevant indicator data.

- The Telecom Regulatory Agency of India is a good example here; it performs this type of joint measurement for 23 regions of the country to ensure the validity of QoS data.