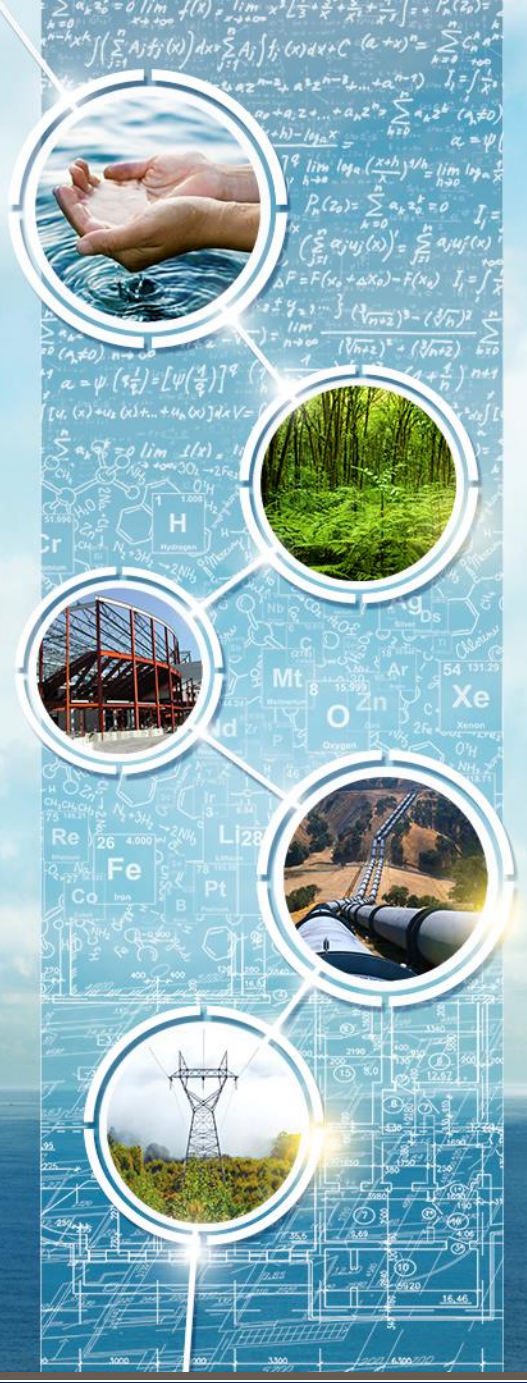

Quality of Service

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Agenda

- Definitions
- QoS Internet Regulation
- Problems with QoS
- QoS Vs. QoE
- Role of Regulators
- QoS in Packet Networks
- QoS in Consumer Protection
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Definition

- Quality of service (QoS) is the ability to treat packets differently as they transit a network device, based on the packet contents. QoS helps manage packet loss, delay and jitter on your network infrastructure.
- It is the description or measurement of the overall performance of a service, such as a telephony or computer network or a cloud computing service, Smart city sensors, particularly the performance seen by the users of the network.
- QoS configuration performs different tasks based on the direction of traffic flow and location of the device performing the QoS functionality.
- At the access layer, where the IP packet first enters the network, QoS policies classify and mark each packet. They then attach a series of rules or policy to the packet based on the decisions made by network and application admins.

Definitions Continued

- Once network and application administrators identify the applications that need to have priority over bandwidth on a network, the next step is to identify the traffic.
- There are several ways to identify or mark the traffic.
  - Class of Service (CoS) and Differentiated Services Code Point (DSCP).
    - CoS will mark a data stream in the layer 2 frame header while DSCP will mark a data stream in the layer 3 packet header.
    - Various applications can be marked differently, which allows the network equipment to be able to categorize data into different groups.
    - now that we can categorize data steams into different groups, we can use that information to place policy on those groups to provide preferential treatment of some data streams over others.
- Once a packet has been marked on the inbound path, the same marking can be used on the outbound path to give each packet access to the appropriate amount of resources.
- As the packet travels through the network, each device simply applies policies based on existing markings and does not need to do an in-depth analysis of the content of each packet.

Definitions

- However, without QoS policies, each packet is instead given equal access to resources.
  - If we cannot tell a voice packet from a data packet, we cannot give voice priority.
- While the most common use cases for QoS have been voice and video streams. There are also many other different types of uses, that need to be given priority, such as IoT devices.
  - For example in the manufacturing sector, machines are beginning to leverage the network to provide real-time status information on any issues that may be occurring.
    - Delays in the identification of a problem can result in manufacturing mistakes costing tens of thousands of dollars each second.
  - With QoS, the manufacturing status data stream cannot take priority in the network to ensure information flows in a timely manner.

- Another use case might be in the steaming of various smart sensors for large-scale IoT projects such as a smart building or smart city.
  - Much of the data collected and analyzed, such as temperature, humidity, and location awareness, is highly time sensitive.
  - Because of this time sensitivity, this data should be properly identified, marked and queued accordingly.

Quality of Service Parameters

- QOS refers to the capability of a network to offer a service with a certain quality. The quality of a service can be related to a number of different parameters. Parameters are:
  - Availability of a link;
  - Number of bit errors;
  - Latency (delay in the network);
  - Jitter.
- Other related aspects of the network service are also considered, such as:
  - packet loss,
  - bit rate,
  - throughput,
  - transmission delay,
  - availability,
  - jitter, etc.

QoS Requirements

- Quality of service comprises requirements on all the aspects of a connection, such as service response time, loss, signal-to-noise ratio, crosstalk, echo, interrupts, frequency response, loudness levels, and so on.
  - A subset of telephony QoS is grade of service (GoS) requirements, which comprises aspects of a connection relating to capacity and coverage of a network, for example guaranteed maximum blocking probability and outage probability.
- For Computer networking and other packet-switched telecom networks, quality of service refers to traffic prioritization and resource reservation control mechanisms rather than any particular level of service quality.
- Quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow.

QoS: Internet Regulation

- Quality of service (QoS) will be a key issue in Internet regulation.
  - Regulation of Internet QoS has its closest reference point in the telecommunications model, which has historically been tightly regulated in terms of universal access, price and quality.
  - This is understandable because access to the Internet is usually through communication links, whether phone lines, cables or the wireless spectrum.
  - First, QoS standards have tended to focus on technical, network measures rather than other qualitative variables.
    - Relying on technical measures for QoS standards obscures the nature of service.
  - What kind of service is the Internet?
    - Is it a service that sells "bits per second"?
    - In this case, even bandwidth is not a service guarantee; it is only an estimate of the speed that packets will go on the network.
    - In reality, capacities have to factor in the amount of congestion on the bandwidth. Bandwidth and other network statistics are estimates rather than accurate measures of service quality.

QoS: Internet Regulation (continued)

- it is difficult to measure QoS standards because of the Internet's technical setup
- The Internet routes traffic around faults, so there is no specific route that the traffic will take.
  - Data are broken down into packets, and each finds its own way, before combining at the end point.
- One way of promoting higher service quality is to create incentives for access providers to go beyond the minimum standards
  - quality of service will help differentiate between levels of service and access provision. Quality of service may be necessary for tariff purposes.
  - Pricing and billing strategies for Internet access may have to partly depend on service quality levels that are requested or provided.

Problems with QoS

- The problems of QoS are among the biggest issues in telecom.
- In many countries, quality is poor on all parameters, e.g. outage, repair time, voice quality etc.
- The convergence from circuit switched telephony to packet-switched telephony bring two questions to mind.
- Whether and to what QoS issues have changed with the transitions from circuit-switched telephony to the present and future multi-service packet-switched environment.
- Whether there is a need for public regulation regarding QoS and, if so, which kind of regulation.
- Quality of Service and Quality of Experience

Quality of Service Vs. Quality of Experience

- Quality of Service was defined as representing all the characteristics of a network connection, such as bit rate, latency, packet loss, jitter, and so forth. Different services require different levels of QoS in order to function
- Quality of experience is used to represent a user's perception of a particular service, typically in a holistic way that assesses the overall level of satisfaction the user had in using the service
- The areas where regulation can have a role to play are in connection with service level agreements (SLAs) in relation to interconnection agreements between dominant market players and competitors depending on the quality of the interconnection services delivered by the dominant operators

Role of Regulators

- The role of regulation must be adapted to these circumstances.
- Standards providing the basis for QoS communication are mostly developed in international standardization organizations and are implemented by the market players in their international and national operations.
- The role of regulators can be to promote these standards and even enforce them if necessary.
- Market players will see it as being in their best interest to implement the standards developed and no regulatory interventions will, therefore, be necessary with respect to standards implementation.

- Quality of service is particularly important for the transport of traffic with special requirements.
  - In particular, developers have introduced Voice over IP technology to allow computer networks to become as useful as telephone networks for audio conversations, as well as supporting new applications with even stricter network performance requirements.
- In packet-switched networks, quality of service is affected by various factors, which can be divided into human and technical factors.
  - Human factors include: stability of service quality, availability of service, waiting times and user information.
  - Technical factors include: reliability, scalability, effectiveness, maintainability and network congestion.

Qos in Packet Networks

- Many things can happen to packets as they travel from origin to destination:
  - Speech Compression and Firewalls
  - Low throughput
    - Due to varying load from disparate users sharing the same network resources, the bit rate (the maximum throughput) that can be provided to a certain data stream may be too low for realtime multimedia services if all data streams get the same scheduling priority.
  - Dropped packets
    - The routers might fail to deliver (drop) some packets if their data loads are corrupted, or the packets arrive when the router buffers are already full. The receiving application may ask for this information to be retransmitted, possibly causing severe delays in the overall transmission.
  - Errors
    - Sometimes packets are corrupted due to bit errors caused by noise and interference, especially in wireless communications and long copper wires. The receiver has to detect this and, just as if the packet was dropped, may ask for this information to be retransmitted.

QoS in Packet Networks (continued)

- Latency
  - It might take a long time for each packet to reach its destination, because it gets held up in long queues, or it takes a less direct route to avoid congestion.
  - In some cases, excessive latency can render an application such as VoIP or online gaming unusable.
- Jitter
  - Packets from the source will reach the destination with different delays. The delay varies with its position in the queues of the routers along the path between source and destination and this position can vary unpredictably.
  - This variation in delay is known as jitter and can seriously affect the quality of streaming audio and/or video.
- Out-of-order delivery
  - When a collection of related packets is routed through a network, different packets may take different routes, each resulting in a different delay. The result is that the packets arrive in a different order than they were sent.
  - This problem requires special additional protocols responsible for rearranging out-of-order packets to an isochronous state once they reach their destination.
  - This is especially important for video and VoIP streams where quality is dramatically affected by both latency and lack of sequence.

QoS in Packet Networks (continued)

- Some types of service are called inelastic, meaning that they require a certain minimum bit rate and a certain maximum latency to function.
  - Examples are: Streaming media
  - IP telephony
  - Videoconferencing applications
  - Safety-critical applications
  - Network operations support systems
  - Online games
  - Industrial control systems protocols
- By contrast, elastic applications can take advantage of however much or little bandwidth is available.
  - Bulk file transfer applications that rely on TCP are generally elastic.

QoS in Packet Networks (continued)

- Unlike QoS issues for telephony, for Internet related traffic, Quality of service is managed different. Since the Internet is configured as best effort QoS can only be managed through the use of the following solutions.
- Over provisioning, that is having extra capacity in the network so that congestion is not a problem, and
- Prioritizing communications so that, for instance, real time communication is given priority over less time-dependent services
- Using appropriate speech codes and managing and optimizing buffer and packet sizes
- These principles are very similar for ensuring QoS for Mobile telephony.

QoS in Mobile Telephony

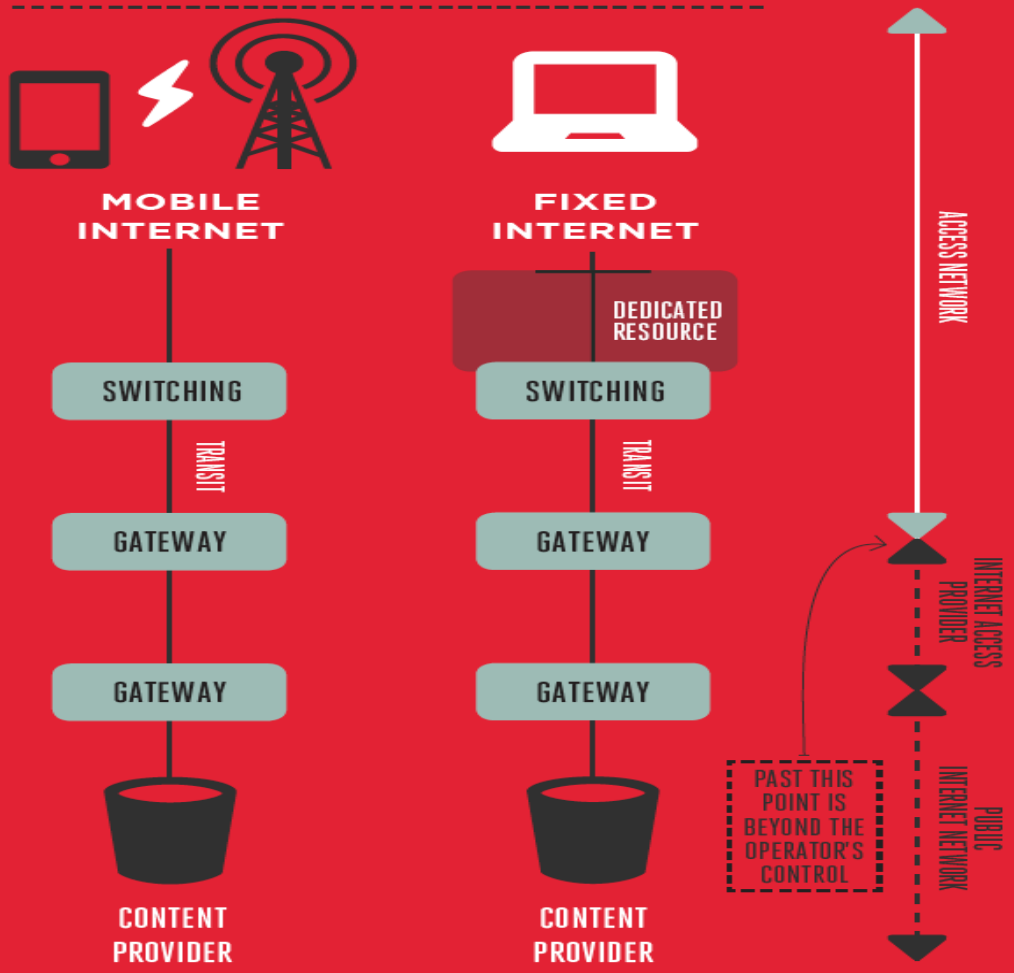
- Quality of Service issues are different for Mobile Telephony than for Fixed Telephony.
- Many of the same QoS issues discussed for Q0S over the Internet often relate to Mobile Telephony as well

MOBILE NETWORKS CANNOT BE MEASURED IN THE SAME WAY AS FIXED NETWORKS

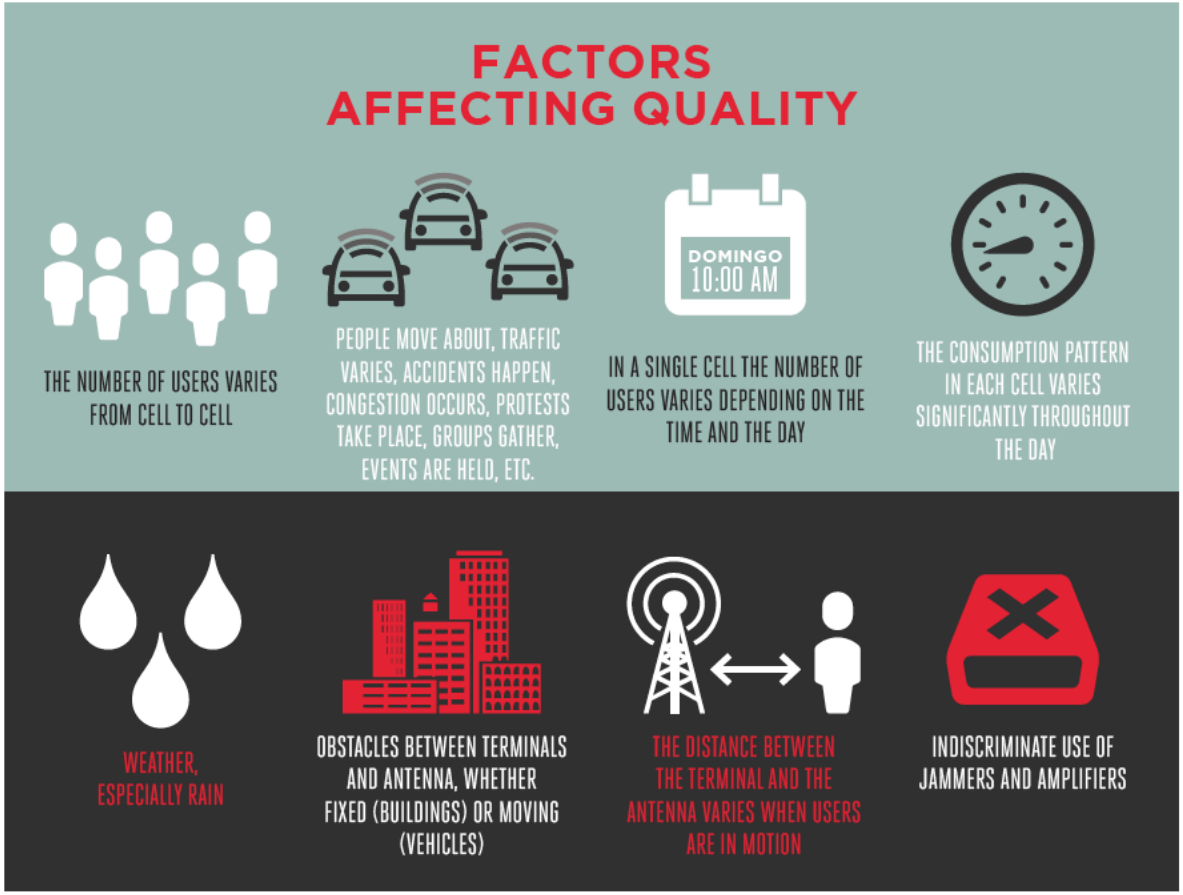
MOBILE ACCESS NETWORKS ARE BUILT ENTIRELY OF SEGMENTS THAT SHARE RESOURCES AMONG SEVERAL USERS

THE FIRST SEGMENT OF THE CONNECTION, FROM THE TERMINAL TO THE ANTENNA, IS AVAILABLE TO EVERYONE WHO DEMANDS IT, PROVIDED SPECTRUM CAPACITY EXISTS.

THE ANTENNA HAS FINITE CAPACITY THAT DEPENDS ON NETWORK PLANNING AND DESIGN, TECHNICAL CAPABILITIES OF THE EQUIPMENT, THE AMOUNT OF SPECTRUM AND THE FREQUENCY BAND IT USES.



Factors Affecting Quality



Quality of Service requirements

- According to the 2017 ITU QoS manual, QoS is being monitored in at least 158 countries
- QoS requirements have been applied to voice services (provided by telecommunication operators), but more recently regulators have been incorporating minimum QoS requirements for data services (through Internet access service (IAS)).
- These requirements can vary from high level transparency guidelines on how the information on traffic management techniques is disclosed to end-users, to requiring actual indicators for data network performance for fixed and mobile broadband providers.
- QoS monitoring is required in 82 per cent of the 193 ITU Member States.

QoS Regulatory Framework

QoS regulatory framework

- **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**

QoS Regulatory Models

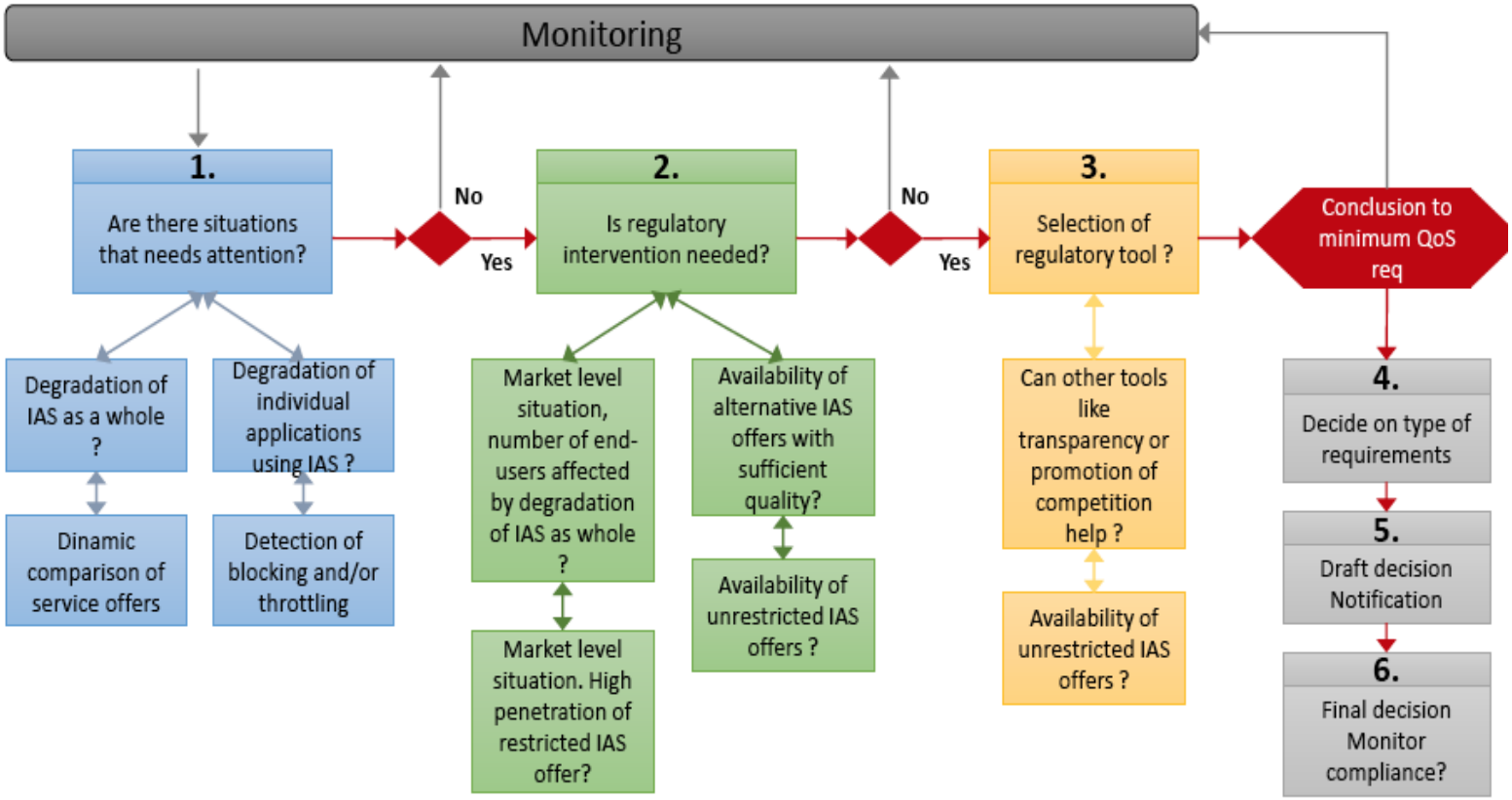
- QoS regulation is directly related to QoS monitoring.
- Different regulatory approaches can be used to implement a quality monitoring system, including:
  - Traditional regulation: The quality monitoring system may be implemented and run by the regulatory authority, either by the authority itself or by using an independent measurement provider.
    - With a sufficient legal basis, the regulatory authority may also impose the establishment of a quality monitoring system on the operators. This option allows full control over the methodology for implementation, as well as the generated measurement data.
  - Co-regulation: The regulatory authority in some cases may find it appropriate to establish joint regulator-stakeholder systems, rather than imposing implementation merely on the operator.

QoS Regulatory Models (continued)

- Self-regulation: The regulatory authority may decide to leave measurement systems to be deployed by the market, and to promote self-regulatory initiatives, as well as publishing monitoring results.
  - For example, NRAs may launch education and information campaigns to increase consumer awareness of the availability and use of measurement tools, while inviting operators to make available user friendly tools to their customers.
  - With this method, the regulatory authority may have some influence, but does not control the methodology of the QoS monitoring system, its implementation or generated data from measurements.

Regulatory issues related to QoS

Main regulatory issues related to QoS in the context of Internet access



QoS in Consumer Protection

- Quality of service is important for consumers and should be part of consumer protection regulation.
- The customer/user should have access to QoS information in a clear, transparent, publicly available and appropriate manner.
- In the GSR 2014 Best Practices report it suggested that measures be taken to ensure consumers including people with disabilities have easy and reliable access to ICT services as well as web content, monitoring network service providers, regularly assessing telecommunication/ICT services quality and publishing the results.
  - They further stressed that regulators need to ensure that all service providers make available timely and accurate information about their services and products in a clear, transparent and comparable manner that is conducive to rational decision making.
  - consumers should "*be able to understand the nature of the services and the quality of service provided, in addition to their own rights and responsibilities. All regulations related to consumers' right to information should be regularly and consistently updated allowing it to be practical and enforceable.*"

QoS in Consumer Protection

- When QoS regulation is part of consumer protection, the main purposes are:
  - Helping customers be aware of the QoS provided by telecom operators/ ISP through networks (mobile & fixed),
  - 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;
  - Making interconnected networks work well together.

2013 Regulation & Consumer Protection

- *The 2013 Regulation and Consumer Protection in a converging environment suggested the following:*
  - *Update existing legislation/regulations to make them fit for purpose in a converged regulatory framework:*
    - *Tackle any potential technical/infrastructure barriers that may deter consumers from subscribing to new products and services.*
    - *Make full use of relevant complaints statistics when formulating policy.*
    - *Review the framework for content regulation.*
    - *Use impact assessments to support evidence-based policy-making. Consumer education and information:*
    - *Promote sufficient competition and choice for consumers.*
    - *Ensure consumers have access to timely and accurate information, including about speeds and data traffic management.*

2013 Regulation & Consumer Protection

- *Ensure that consumers are informed about potential security and privacy challenges they face and the measures available to limit the risks. Build consumer trust in converged services:*
- *Promote and safeguard e-commerce and mobile commerce by introducing measures to build trust amongst consumers.*
- *Encourage operators to develop security precautions including built-in security features to prevent unauthorized transactions and data breaches, implementation and enforcement issues.*
  - *Provide for a strong, well-resourced consumer protection regulatory team or separate agency with communications expertise.*
  - *Agree on a clear division of responsibilities among the agencies concerned.*
  - *Distinguish between implementation failures versus underlying legislation.*

Enforcement

- Enforcement mechanisms of quality of service include the following:
  - reports of QoS submitted monthly or quarterly by telecommunication operators to the NRA (may Include technical and non-technical parameters);
  - QoS monitoring tools for auditing;
  - penalties and disincentives;
  - independent customer surveys and their publication

Quality of Service Regulation in a Converged Environment

- Regulatory frameworks need to be modified so as to take full advantage of these new converged services and still maintain a certain level of QoS
  - In the traditional regulatory framework ensuring certain QoS standards has been a main function of the regulator.
  - However in a converged environment, new technologies have blurred the boundaries between the broadcasting and telecommunications sectors.
- Quality of Service Standards
  - New QoS standards must be created for converged services since each of the services has very different QoS requirements.
  - Telecom has more stringent QoS standards because it has to be always available, but broadcasting because it was one to many and not one to one may have very different requirements.
  - Traditionally broadcasters have not allocated resources dynamically. Instead, broadcasting towers, satellite networks, serve customers in a static fashion since signal transmission is independent of the usage.

- Defining appropriate and transparent QoS requirements can assist operators to provide quality services at affordable costs to consumers and regulatory authorities have a key role to play.
- Consultation and collaboration between regulatory authorities and regional and international organizations, including ITU, is very important in developing QoS regulation, and in particular monitoring and measurement tools

Conclusion

- Regulation and management of QoS and QoE today are becoming increasingly important and complex with a profusion of ever evolving technologies, networks and services with different QoS capabilities in a highly competitive, challenging and globalized digital environment
- Overall, the aim of QoS regulation remains to ensure fairness and high quality user experience
  - QoS regulation is directly related to QoS monitoring.
- Different regulatory approaches can be used to implement a quality monitoring system
- Defining appropriate and transparent QoS requirements can assist operators to provide quality services at affordable costs to consumers and regulatory authorities have a key role to play.

Conclusion

- Consultation and collaboration between regulatory authorities and regional and international organizations is very important in developing QoS regulation, and in particular monitoring and measurement tools
- NRAs should have the appropriate skill set to carry out QoS regulation; therefore continuous capacity building is key to adapting to market and regulatory changes.
- NRAs can benefit greatly by learning from each other. The arguments for cooperation between regulators are very strong and can bring substantive benefits through the sharing of good practices and mutual learning.

Thanks
Questions, Comments, Suggestions

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