QoS Monitoring and Compliance





DAY 4

1. BASICS OF TELECOM TRAFFIC
2. TELECOM NETWORKS AND PERFORMANCE INDICATORS
3. BROADBAND
4. INTERCONNECTED NETWORKS

BASICS OF TELECOM TRAFFIC

Telecom Traffic Characteristics

- **Telecommunications traffic or teletraffic :** a process of events related to demands for the utilization of resources in a telecommunication network [ITU-T E.600].
- **Resource:** any set of physically or conceptually identifiable entities within a telecommunications network, the use of which can be unambiguously determined.





Traffic Intensity Concepts

- In a broad sense, traffic intensity relates to the rate that work arrives to a traffic system and the resources needed to handle the work. [ITU T E.500]
- The class of traffic systems consists of a pool of resources of a single type jobs that:
  - arrive and seize a needed amount of resources
  - wait until the resources are available
  - leave if there are insufficient available resources and insufficient waiting room
- A holding time per job, is the time for a specified quantity of dedicated resources to complete its work.








Traffic Intensity Concepts

- Some important examples are:
  - Circuit Groups – The job is the call, the resources are the specified number of circuits required by the call, and the holding time for a job is the call holding time.
  - Call Processing – The resource is a call processing CPU, the job is a call, and the holding time for the job is the CPU processing time for the call.
  - Packet Data Transport – Fixed bandwidth data transmission channel, to transport a data packet over the transmission channel, and the holding time for a job is the time it takes to transmit the packet ([packet length]/[data channel speed]).

Traffic Intensity Concepts

- Average traffic intensity is measured over time intervals - *read-out periods* [ITU-T E.492].
- The length of the read-out period must be chosen so that acceptable estimates of traffic intensity are obtained.








Traffic Intensity Concepts

- The instantaneous traffic in a pool of resources is the number of busy resources at a given instant of time [ITU E. 500].
- Statistical moments may be calculated for a given period of time,
- In applications, the term traffic intensity usually has a meaning of mean traffic intensity.
- Traffic intensity is equivalent to the product of arrival rate and mean holding time.

Traffic Intensity Unit

- **Erlang:** Unit of traffic intensity (symbol: E).
  - 1 erlang is the traffic intensity in a pool of resources when just one of the resources is busy.
  - Erlang represents the average number of busy resources over the time interval *(t1,t2)*.
- **Traffic volume:** The traffic volume in a given time interval is the time integral of the traffic intensity over this time interval.
  - Traffic volume is equivalent to the sum of the holding times in the given time interval.
  - A unit of traffic volume is the Erlang hour (symbol: Eh).




Traffic Arrival and Disposal Pattern

- **Poisson traffic; pure chance traffic**
  - Traffic that has a Poisson distribution of arrivals.
  - Poisson traffic has a peakedness factor equal to 1.
- **Peakedness factor:** the ratio of variance to mean of traffic intensity
- **Peaked traffic :** Traffic that has a peakedness factor greater than 1.
- **Smooth traffic :** Traffic that has a peakedness factor less than 1









Traffic Measurement and Evaluation

- A good knowledge of the traffic in the network is important for planning and operating telecommunication networks
- Service functionality parameters can be measured using real traffic or using test traffic which is comparable for different operators
- The size of the traffic streams, how they vary with time of the day, week and year, and their distribution in the network
- Traffic Measurement is necessary to plan and operate different parts of the network to gives the lowest network cost at the preplanned grade of service [ITU-T E. 490].

Traffic Measurement and Evaluation

- Weeks, days or hours measurements are important for detecting and correcting faults affecting traffic.
- Years, months measurements are used to make traffic forecasts as a basis for network extensions and long-term network configuration.
- For engineering applications a mean traffic intensity value, representing high traffic periods of the day and year, is generally used.





Other Important Factors

- Other most important factors, which have a heavy impact on network planning and reconfiguration
  - marketing activities;
  - tariff policy;
  - commercial agreements;
  - strategic objectives.





Traffic Measurement Parameters

- **Bid:** A single attempt to obtain the use of a resource of the type under consideration.
- **Seizure :** A bid that obtains the use of a resource of the type under consideration.
- **Idle (state):** Condition of a resource that is free to be seized.
- **Busy (state):** condition of a resource following its seizure.
- **Release:** the event which changes the condition of a resource from busy to idle.



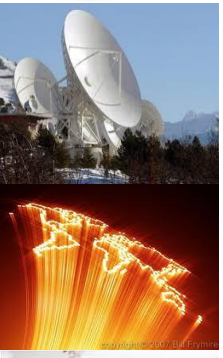

Traffic Measurement Parameters

- **Holding Time:** the time between the seizure of a resource and its release.
- **Blocked mode of operation:** A mode of operation in which bids which find no suitable resources idle and accessible are not permitted to wait.
- **Delay mode of operation:** A mode of operation in which bids which find no suitable resources idle and accessible are permitted to wait. **Call congestion:** The probability that a bid to a particular pool of resources will not result in an immediate seizure.
- **Time congestion:** The proportion of time that a particular pool of resources does not contain any idle resource.
- **Waiting time; queuing time:** In delay mode of operation, the time interval between the bid for a resource and its seizure.




Traffic Intensity Measurement Methods

- **Daily Peak Period (DPP):**
  - consecutive read-out periods of each day and
  - the peak traffic intensity for the day is recorded on continuous basis .
- **Fixed Daily Measurement Interval (FDMI):**
  - a predetermined time interval (a set of consecutive read-out periods during a day) in which peak period loads usually occur is identified,
  - during that time interval each day traffic intensity measurements are taken.
  - the peak traffic intensity over the measured read-out periods is recorded for the day.




Traffic Load Conditions

- **Normal load condition:** frequent busy operating conditions for which user expectations should be met.
- **High load condition:**
  - not very frequently encountered operating conditions for which user service expectations would not necessarily be met,
  - But the level of performance achieved high enough to avoid significant user dissatisfaction, spread of congestion, etc
- **Normal (high) load traffic intensity:** the representative value over a monthly time interval of the traffic intensity under normal (high) load condition
- **Yearly Representative Value (YRV) of the normal (high) load traffic intensity:** the representative value over a yearly time interval of the traffic intensity under normal (high) load condition.

Traffic Measurement Principles and Evaluation

- Measurement methods and evaluation procedures.
- Methods and applications of traffic measurements on a destination basis are handled in ITU-T Rec. E.491.
- The traffic measurement requirements for digital telecommunications exchanges [ITU-T Rec. E.502].
- Measurements of the performance of common channel signalling networks [ITU-T Rec. E.505].
- Administration of scheduling and ordering of traffic measurements and control of traffic data collection [ITU-T Rec. E.504].
- Models and procedures for analysis of recorded traffic data [ITU-T Rec. E.503].





Application of Traffic Measurements

- Forecasting purposes [ITU-Rec E.506 to E.508]
- Engineering network extensions [ITU-T Rec. E.510- and E.520-Series]
- Network management actions[ITU-T E.410-Series]
- Traffic measurement classified according to the time frame for using observed traffic data for network actions.[ITU-T Rec. 490]
- Another type of classification used according to the measurement basis (objects), e.g. circuit groups [ITU-T Rec. E.503]
- Although developed on the experiences of public switched telephone network (PSTN), may apply to other switched networks.








Telephone Traffic Models

- All telephone network dimensioning procedures are based on mathematical models that approximate the statistical behaviour of telephone traffic in large populations [ITU-T Rec. E.731].
- The models allow straightforward characterization of the traffic demand and network dimensioning by adopting simplifying assumptions concerning:
  - Stationarity of the traffic process during the reference period;
  - Call attempt inter-arrival times;
  - Call holding times;
  - Disposition of blocked or delayed call attempts;
  - Dependency of call attempts and holding times from network state and other call attempts.

Traffic Models and Traffic Tables

- Telephone Traffic Models [ITU-T Rec. E.731]
- Circuit Switched ISDN Models
- User Demand Modelling [ITU-T Rec. E.711]
- Control Plane Traffic Modelling [ITU-T Rec. 713]
- User Demand Modelling in Broadband ISDN [ITU-T Rec. 716]





Telephone Traffic Models

- In the most commonly used Erlang loss formula, the following assumptions are used:
  - Stationary traffic process during the reference period;
  - Poissonian arrival of call attempts;
  - General distribution of call holding times;
  - Blocked calls cleared;
  - Independence of call attempts and holding times on network state and other call attempts.







Traditional Telephone Traffic Models

- Circuit Switched ISDN Models
- User Demand Modelling [ITU-T Rec. E.711]
- Control Plane Traffic Modelling [ITU-T Rec. E.713]
- User Demand Modelling in Broadband ISDN [ITU-T Rec. E.716]
- Terminal Mobility Traffic Modelling [E.760]





Traditional Telephone Traffic Models

- The number of circuits needed for a group is read from tables or curves based on the classical Erlang B formula based on full availability groups of circuits [ITU-T E. 520]
- Recommended methods for traffic determination are indicated in Recommendation E.500.
  - For *semi-automatic operation the loss probability p should be based on 3% during the mean busy hour.*
  - For *automatic operation the loss probability p should be based on 1% during the mean busy hour.*
- Semiautomatic traffic using the same circuits as automatic traffic is to be added to the automatic traffic and the same parameter value of *p = 1% should be used for the total traffic.*
- The values of 3% and 1% quoted above refer to the Erlang B formula and derived tables and curves. The 3% value should not be considered as determining a grade of service because with semiautomatic operation there will be some smoothing of the traffic peaks; it is quoted here only to determine the value of the parameter *p (loss probability)* to use in the Erlang B tables and curves.




Models For Forecasting Traffic

- The two different strategies for forecasting are the direct strategy and the composite strategy [ITU T E.506].
- The first step in either process is to collect raw data.
- The raw data, perhaps adjusted, will be the base data used to generate the traffic forecasts.
- Base data may be hourly, daily, monthly, quarterly, or annually. These data may be adjusted to account for occurrences[ITU T E.500].
- With the direct strategy, the traffic carried in erlangs, or measured usage, for each relation would be the base data in forecasting traffic growth.

Models For Forecasting Traffic

- Various traffic forecasting can be used [ITU T E.507]
- Smoothening model: simple and double exponential smoothing, discounted regression, etAutoregressive models
- Autoregressive integrated moving average (ARIMA) models or econometric models.
- Econometric and time series model: involves equations relating a variable to forecast (the dependent or endogenous variable) to a number of socio-economic variables (independent or explanatory variables).
- Historical or cross sectional data are used to estimate coefficients in the equation.




Telephone Traffic Tables

- Telephone traffic table are used for the purposes of estimating the circuits and the capacity of the switches
- In acase of IP networks, the information trasfer capacity or the trasmission speeds




TELECOM NETWORKS AND PERFORMANCE INDICATORS

Public Switched Telephone Networks

- Basic Functions of a Telephone Network
- Switching areas and service environment
- Long distance network
- Key Performance Indicators of PSTN and their measurement
- Call Completion and related parameters; how they are affected by the network and its operational management




Basic Functions of a Telephone Exchange

- Digital local, combined, transit and international exchanges for telephony in:
- Integrated Digital Networks (IDN)
- Mixed (analogue/digital) networks and local, combined, transit and international exchanges in an Integrated Services Digital Network (ISDN).





Exchange Functions

- The telephone exchange can be divided into three functional areas:
  - Control functions – control services and connections, e.g. signalling, routing and connection/resources handling functions;
  - Connection functions – directly related to the connection path through an exchange, i.e. switching and transmission mechanism (including ET);
  - Operation and maintenance functions – of an operational, management and maintenance nature which are not employed for call establishment and supervisory purposes, e.g. test functions.








Exchange Functions

- The division is appropriate to exchanges operating in IDN and in ISDN.
- Most of the functions fall within the control functions area.
- Connection functions: address the basic switch characteristics of different connection types[Q.500 and Q. Q.522].
- OA&M functions [Q.542].

Exchange Connections

- The characteristics of the connections refer to an established connection when it is made available to the users.
- An exchange must be able to provide originating, terminating and internal exchange connections between input and output interfaces for telephony and other services as required:
- Transit connection: between an incoming and an outgoing circuit at interfaces to other exchanges/networks.
- Originating connection: between channel(s) of a calling subscriber line at an interface for subscriber access and an outgoing circuit at an interface to other exchange/networks
- Terminating connection – between an incoming circuit at an interface to other exchange/networks and channel(s) of a called subscriber line at an interface for subscriber access
- Internal connection: between channels of two subscriber lines at interfaces for subscriber access




Exchange Connections

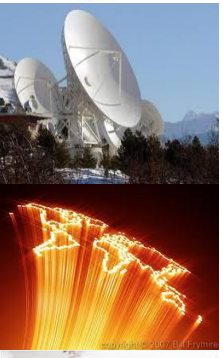
- An exchange must be able to provide:
  - Bidirectional connections between input and output interfaces for telephony and other services as required.
  - Unidirectional connections may be required.





Switching Area and Service Environment

- Area serviced by the switching system
- The switching area can be a geographical region service by the switching system



Long Distance Network

- International Networks providing connecting one country to the other
- Regional network providing regional connections





QoS of Telecommunication Network

- Telecommunications systems
  - The technical equipment or systems capable of sending, transmitting, switching, receiving, steering or controlling messages identifiable as electromagnetic signals.
- In a circuit-switched telephony environment, QoS refers to:
  - Call completion rate,
  - Downtime,
  - Noise etc. and
  - The underlying technical parameters for securing a sufficient voice quality.




QoS of Telecommunication Network

- QoS in a connection-less packet-switched Internet environment is similar to PSTN
- In Internet the quality as perceived by the users can be measured and the technical parameters to secure a sufficient quality can be determined.
- Circuit-switched PSTNs are optimized for voice service, while Internet is optimized for data transfer.
- QoS denotes the capability of the network infrastructure, client applications and the end user terminals to deliver a service living up to certain quality levels.
- QoS requirements vary from service to service and depend directly on the specific services.

QoS of Telecommunication Network

- In POTS, for example, there are detailed recommendations on QoS from ITU on maximum delay, blocking rate, MOS (Mean Opinion Score) etc.
- Connectionless or connection oriented
  - Connection is used in the context of establishing communication between two points in a network.
  - Connection is "bearer path, label switched path, virtual circuit, and/or virtual path established by call routing and connection routing". (ITU-T E.360.1; ITU-T E.361)
- Specified Operating Conditions such as:
  - Environmental conditions
  - Traffic and Routing





KPIs PSTN and their Measurement

PSTN Service	QoS Parameter	Measurement
Voice Telephony	Unsuccessful call ratio	
	Call setup time	
	Mean Opinion Score	
	Blocking Rate	
	Speech connection quality	
Fax Transmission	Fax connection quality	
Data Transmission	Data rate of dial-up access to the Internet	
SMS	Successful SMS ratio	
	Completion rate for SMS	
	End-to-end delivery time for SMS	





Call Completion Parameters

- **Call :** A generic term related to the establishment, utilization and release of a connection. Normally a qualifier is necessary to make clear the aspect being considered, e.g. call attempt.
- **Call intent:**
  - The desire to establish a connection to a user.
  - This would normally be manifested by a call demand.
  - However, demands may be suppressed or delayed by the calling user's expectation of poor Quality of Service performance at a particular time.
- **Call demand:** A call intent that results in a first call attempt.
- **Call attempt:**
  - An attempt to achieve a connection to one or more devices attached to a telecommunications network.
  - At a given point in the network a call attempt is manifested by a single unsuccessful bid, or a successful bid and all subsequent activity related to the establishment of the connection.








Call Completion Parameters

- **First call attempt:** The first attempt of a call demand that reaches a given point of the network.
- **Repeated call attempt; reattempt:**
  - Any of the call attempts subsequent to a first call attempt related to a given call demand.
  - Repeated call attempts may be manual, i.e. generated by humans, or automatic, i.e. generated by machines.
- **Call string:** All the call attempts related to a single demand.





Call Completion Parameters

- **Blocked call attempt:** A call attempt that is rejected owing to a lack of resources in the network.
- **Abandoned call attempt:** A call attempt aborted by the calling user.
- **Fully routed call attempt; successful call attempt**: A call attempt that receives intelligible information about the state of the called user.
- **Completed call attempt; effective call attempt:** A successful call attempt that receives an answer signal.



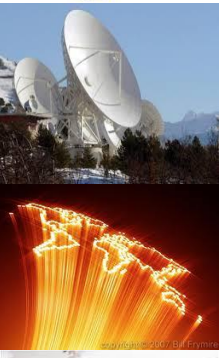

Call Completion Parameters

- **Successful call:** A call that has reached the wanted number and allows the conversation to proceed.
- **Completion ratio:** The ratio of the number of completed call attempts to the total number of call attempts, at a given point of a network.
- **Answer seizure ratio (ASR):** On a route or a destination code basis, and during a specified time interval, the ratio of the number of seizures that result in an answer signal, to the total number of seizures.
- **Answer bid ratio (ABR):** the ratio of the number of bids that result in an answer signal, to the total number of bids.
- **Calling rate:** The number of call attempts at a given point, during a specified time interval, divided by the

Effect of Network on Completion Parameters

Effect of Network on Completion Parameters

Effect Operational Management on Call Completion Parameters



Public Land Mobile Networks (PLMN)

- Overview and definitions:
  - Basic definitions
  - Roaming
  - Handover
- Architectures
  - Roaming Situation
  - Handover situation.
- Services
  - Basic services
  - Supplementary services
- Mobile Number Portability





Basic definitions

- **Public Land Mobile Services**
- Telecommunications services provided to moving subscribers (terrestrial applications) [Q.1001]
- **Public Land Mobile Network (PLMN)**
- Established and operated for specific purpose of providing land mobile telecommunication services to the public.
- May be regarded as an extension of a fixed network (e.g. PSTN) or as an integral part of the PSTN.
- Functionally the PLMNs may be regarded as independent telecommunications entities
- Different PLMNs may be interconnected through the PSTN and PDNs for forwarding of calls or network information.
- A similar type of interconnection may exist for the interaction between the MSCs of one PLMN.
- The location register system of a PLMN may be centralized, distributed or segmented. So long as we are concerned with functions of a PLMN, such as routing and interworking, the configuration and operation of the location
- register system have no influence on external networks.




Basic definitions

- **Mobile Services Switching Centre**
- Mobile Services Switching Centre (MSC) constitutes the interface between the radio system and the public switched telephone network.
- The MSC performs all necessary signalling functions in order to establish calls to and from mobile stations.
- To obtain radio coverage of a given geographical area a number of base stations (radio transmitters/receivers) are normally required;
- Each MSC have to interface several base stations.
- Several MSCs may be required in order to cover a country.
- The definition of the MSC may be prefixed by the terms "land" or "maritime" if that is more suitable in a specific application.




Basic definitions

- **Base station:**
- The base station (BS) is the common name for all the radio equipment located at one and the same place used for serving one or several cells.
- **Mobile station**
- The mobile station (MS) is the interface equipment used to terminate the radio path at the user side.
- It includes terminal functions required to provide services to the user, e.g. terminal equipment and terminal adaptors.
- **Cell**
- The area covered by a base station, or by a sub-system (sector antenna) of that base station corresponding to a specific logical identification on the radio path, whichever is smaller.
- Every mobile station in a cell may be reached by the corresponding radio equipment of the base station.
- **Base station area**
- The area covered by all the cells served by a base station.




Basic definitions

- **Location area**
  - An area in which a mobile station may move freely without updating the location register.
  - A location area may comprise several cells.
- **MSC area**
  - The part of the network covered by an MSC.
  - An MSC area may consist of several location areas.
- **service area**
  - An area in which a mobile station is obtainable by another PLMN, PSTN or ISDN subscriber without the subscriber's knowledge of the actual location of the mobile station within the area.
  - A service area may consist of several PLMNs.
  - One service area may consist of one country, be a part of a country or comprise several countries.
  - The location registration system associated with each service area must thus contain a list of all mobile stations located within that service area.





Basic definitions

- **System area**
- The system area consists of one or more service areas with fully compatible MS-BS interfaces.
- **Mobile Subscriber International ISDN Number**
- The Mobile Subscriber International ISDN Number is defined as the number which has to be dialled in order to reach a mobile subscriber in a service area [E.164 and E.213].
- **International mobile station identity**
- The mobile station's identification uniquely identifies the MS internationally. The identity is composed [E.212]
- **Radio traffic path**
- The radio communication facility between a mobile station and a base station intended to carry a call and uniquely assigned to the mobile station during that call.
- **Radio control path**
- The radio communication facility between a mobile station and a base station intended to carry all the information transfer between the mobile station and the MSC, in which area the mobile station currently is located, during the time that no radio traffic path between that base station and that mobile station is assigned.




Roaming definitions

- **Location register**
- Stores the information on where mobile station is located for in order to establish a call to a mobile station the network
- A mobile station is registered at one location register which functions as its home centre for charging and billing purposes and for administering its subscriber parameters.
- **Location information**
- The location register should as a minimum contain the following information about a mobile station:
  - international mobile station identity;
  - actual location of the mobile station (e.g. PLMN, MSC area, location area, as required).
- **Home PLMN**
- The PLMN in which a mobile station is permanently registered.
- **Home location register**
- The location register to which a mobile station is assigned for record purposes such as subscriber information.





Roaming definitions

- **Home MSC**
- The term home MSC (HMSC) may be used in cases where the home location register is implemented in an MSC.
- **Equipment Identity Register**
- The register to which an international mobile equipment identity is assigned for record purposes.
- **Visited PLMN**
- The PLMN, other than the home PLMN, in which a roaming subscriber is currently located.
- **Visitor location register**
- The location register, other than the home location register used by an MSC to retrieve information for,
- Used for handling of calls to or from a roaming mobile station, currently located in its area.




Roaming definitions

- **Visited MSC**
- The term visited MSC (VMSC) may be used in cases where the visitor location register is implemented in an MSC.
- **Gateway PLMN**
- The PLMN which receives a call from a fixed subscriber, via a public switched network, for extension to a mobile station.
- The gateway PLMN may vary for interconnection with different public networks.
- The gateway PLMN could be the home PLMN or the visited PLMN or any other.
- **Gateway MSC**
- The MSC which receives a call from a fixed subscriber, via a public switched network, for extension to a mobile station.
- The gateway MSC may vary for interconnection with different public networks.
- The gateway MSC may be any MSC of the PLMN, including the HMSC or VMSC if the home and visited location registers are implemented in the MSC.







Roaming definitions

- **Designation method**
- The calling subscriber must know the actual location area of any mobile station.
- The call is established according to the dialled information only, i.e. the call is not rerouted by the location register when the mobile station currently is in another location area.
- **Non-designation method**
- The calling subscriber is not required to know the actual location area of the mobile station.
- The call is routed according to the dialled information and, if required, rerouted on additional information given by a location register.
- **Mobile station roaming number**
- The network internal number used for routing of calls to the mobile station [E.213].




Handover definitions

- **Handover**
- The action of switching a call in progress from one cell to another (or between radio channels in the same cell).
- Handover is used to allow established calls to continue when mobile stations move from one cell to another (or as a method to minimize co-channel interference).
- **MSC-A (Controlling MSC)**
- The MSC which first established the radio connection to or from a mobile station for mobile terminating or originating calls respectively.
- This MSC will be the call controlling MSC for the duration of the call also in cases where a call is handed over to another MSC.
- **MSC-B**
- The first MSC to which a call is handed over.




Handover definitions

- **MSC-B':** The second (or subsequent) MSC to which a call is handed over.
- **Candidate MSC:** An MSC which controls cells that could be candidates for receiving a call in case of a handover.
- **Target MSC:** The Target MSC is the MSC controlling the cell(s) selected as target(s) for a handover.
- **Serving MSC:** The Serving MSC is the MSC which handles the call at the moment.
- **Old serving MSC:** The old serving MSC is the MSC which was the serving MSC before a handover, other than MSC-A.

Mobile System Architecture

- Configuration of a Public Land Mobile Network
  - No co-location of functional entities
  - VLR co-located with VMSC
  - HLR and VLR co-located with a MSC
  - OMC
- Interconnection between PLMNs









The Functional Architecture of Mobile System

- MSC, the home location register (HLR), and the visitor location register (VLR), perform the networking and switching functions
- BSS which includes the base stations controller (BSC) and the base station transceivers;
- the operation and maintenance centre (OMC);
- mobile station (MS)

GSM Logical Channels

- Moping purposes: mobile – to – mobile; mobile – to- fixed
- ITU R M1073.1
- The ITU SS No. 7 and the ISUP fuctions





BTS Fault Analysis and Test

- The fault analysis of through the BSS
- The BSS performs the radio channel management functions which include:
  - administration of the radio channel configurations,
  - allocations of radio channels and link supervision, scheduling of messages on broadcast channels,
  - Choice of frequency hopping sequences whenever needed, and
  - power controls





OMC-R Data Analysis

- Operation and Maintenance Centre Records of PLMN for the purposes maintain of the QoS
- OMC-R System processes and nalyses the NP parameters
- The output records are used for planning and maintenance purposes





OMC-R Statistics

- At the network optimization stage, the OMC-R traffic statistics indexes are the basis for network performance optimization.
- For network optimization, the KPIs, such as congestion rate, call drop rate, and handover success rate, are in common use.
- These indexes are the external representation of network quality.
- The radio coverage quality, channel capacity, and cell parameters are the internal factors to affect the network quality.
- The traffic statistics analysis aims to look into these internal factors through external factors.







General Analysis Method(1/2)

- Traffic statistics analysis is performed from BSC overall performance to cell performance, from primary indexes to secondary indexes.
- Understanding of the network performance through BSC performance analysis is important.
- Indexes such as TCH traffic intensity, TCH call drop rate, TCH congestion rate, and inter-cell handover success rate should be considered.
- In addition to check the percentages of the indexes, the absolute numbers of the indexes, because the percentages may sometimes hide some cell problems.

General Analysis Method(1/2)

- After having understood the indexes about the overall network performance, you should analyze the indexes for each cell if finding abnormal indexes.
- First you should judge if the abnormal index is a common phenomenon or it is really an abnormal one.
- If it is a common phenomenon, you should begin the analysis from the perspective of coverage, capacity, frequency planning, and cell parameters.
- If it is really an abnormal case, you should register the corresponding traffic sub-items and analyze them in detail. In addition, you should also make an overall judgment through collecting the information about alarm, engineers' operation, and other external causes.
- If the traffic statistics analysis cannot contribute a correct judgment, you should employ Drive Test equipment and signaling analyzer for help.

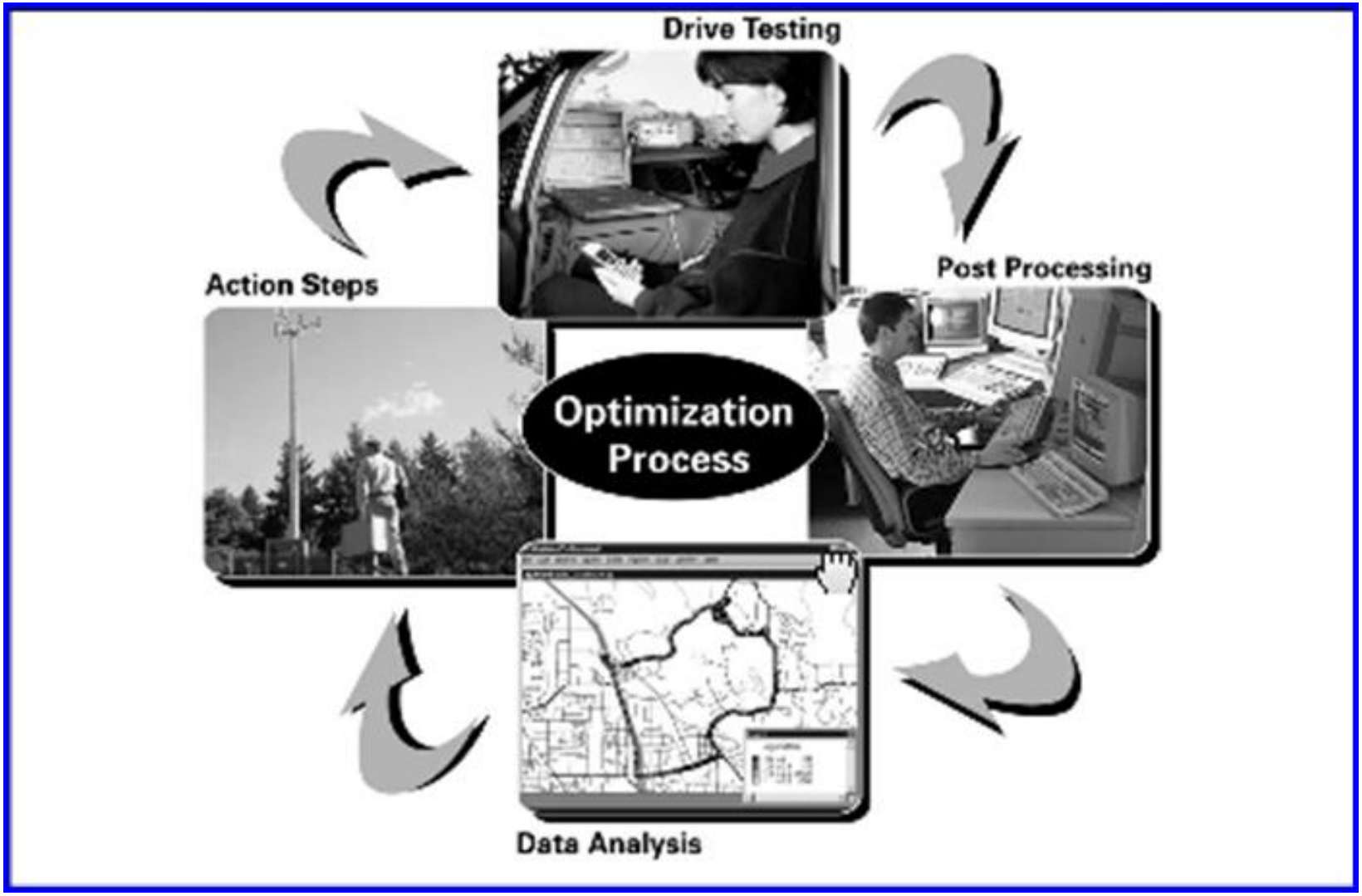



Drive Test and Analysis

- Essence of Drive-test
- Types of Drive-test
- Drive-test tool Setup
- Parameters for testing
- Drive-test for specific cases




Simple Optimisation Process



Essence of Drive Test

- Performing a drive test is always the best way to localize geographically and analyze a problem
- Drive testing or walk testing bring a simulation of end user perception of the network on the field from one call perspective and also gives instant scenario of one area's behaviour during a call.








Types of Drive Test tools

- Troubleshooting and Optimization
- Benchmarking
- The performance of the tool depends on the ability of the handset to report and also the advancement of tool.

Simple Drive Test Tool Setup





Drive Test tool Setup

- One or more handsets, configurable on different technologies like GSM 900/1800/2100 mounted on a car kit and connect via a cable to a laptop, report measurements for specific software.
- This set configuration permits online visualization on a map or a graph of different parameters (level, quality, serving cell identity, etc.).
- Also global positional system GPS needed to help create road traces to be enable viewing of the signal level and quality degradation precisely.




Parameters for Testing

- Main Coverage Area Network
- Network Reception Level (RxLev)
- Reception Quality (RxQual)
- Audio or Video Quality(POLQA)
- Cell Overlapping
- Interference
- Frame Error Rate or Frame Erasure Rate (FER)
- Bit Error Rate or Bit Error Ratio (BER)
- Handovers
- SDCCH Congestion Rate
- Call Set-Up Success Rate (CSSR)
- TCH Congestion Rate (TCHCR)
- Call Drop Rate (CDR)




Drive Test for New Site Integration

- This task consist of measuring the Radio Parameters around the new on air site to enable you generate Radio Acceptance Report.
- By making reference to the main Coverage Area, Reception signal Level (RXLEV), Reception the Signal Quality (RXQUAL), FER and the Best Server Area etc.

Drive Test for Benchmarking

- To compare the performances between operators regarding the Radio Parameters; the following indicators should be reported:
  - Global Coverage Comparison
  - Call Setup Time
  - Call Setup Success Rate
  - SDCCH Congestion Rate
  - TCH Congestion Rate
  - Drop Call Rates
  - Speech Quality Comparison





Factors that can affect Drive Test

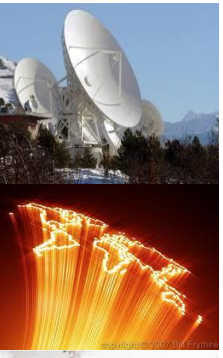
1. Poor road network
2. Terrain
3. Atmospheric conditions
4. Faulty car





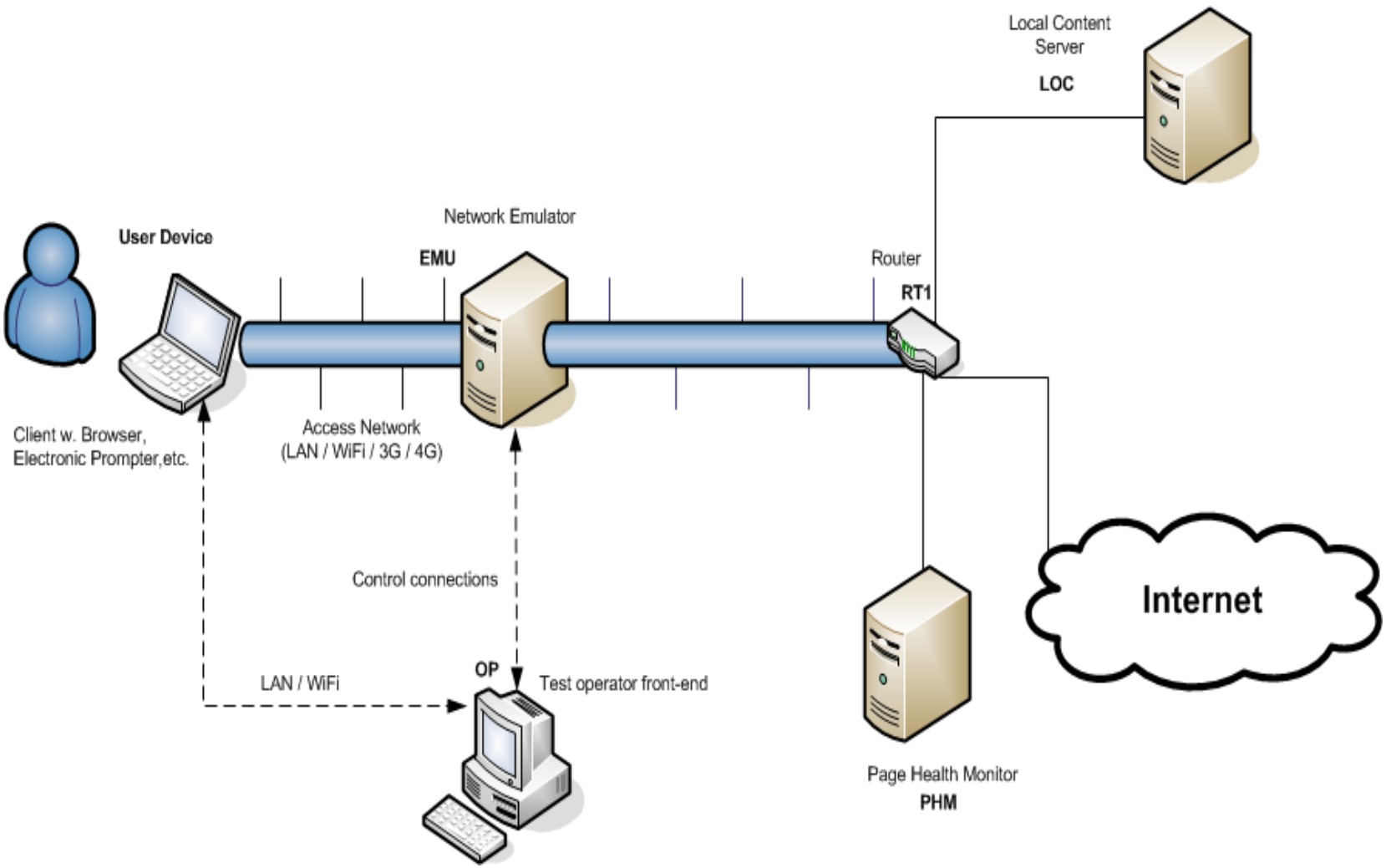
Test Setup for web browsing

Measurement Tools



AFRALTI

Test setup for Rec. P.1501 Quality of web browsing



KPIs of PLMN and Measurement

PSTN Service	QoS Parameter	Measurement
Voice Telephony	Unsuccessful call ratio	
	Call setup time	
	Speech connection quality	
	Dropped call ratio	
	Coverage	
Fax Transmission	Fax connection quality	
Data Transmission	Data rate of dial-up access to the Internet	
SMS	Successful SMS ratio	
	Completion rate for SMS	
	End-to-end delivery time for SMS	







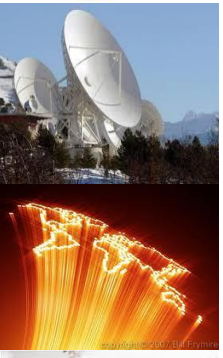

Mobile Number Portability

- Mobile Number Portability (MNP) is defined as the number of transactions (i.e. one number can be ported several times – transactions).
- Total mobile numbers ported within the year.
- While mobile number portability (MNP) is desirable, it is not always necessary and can add considerably to costs and network complexity.
- When quality of service is already an issue it may be desirable to make MNP a secondary priority.

BROADBAND

BROADBAND

- What is Broadband?
- Service Delivery Network
- Basic Service Functions
- Key Performance Indicators
- Performance Measurement



What is Broadband?

- Despite its worldwide growth and promotion by policy makers, network operators, and content providers, broadband does not have a single, standardized definition.
- The term "broadband" refer to multiple aspects of the network and services, including:
  - Infrastructure or "pipes" used to deliver services to users,
  - high-speed access to the Internet, and
  - services and applications available via broadband networks, such as:
    - Internet Protocol television (IPTV) ;
    - and voice services that may be bundled in a "triple-play" package with broadband Internet access.








Definition of Broadband

- Many countries have established definitions of broadband based on speed or functionality:
- Speed: measured in Mbit/s or Kbit/s is the amount of data that can be transmitted across a network connection in a given period of time, typically one second
- Speed measurement is also known as the data transfer rate or throughput.
- Functionality: refers to the types of services and applications used over a broadband network.
- Definitions of broadband vary widely due to each country's unique needs and history, including economic, geographic, and regulatory factors.

Definition by Functionality

- Broadband defined in terms of functionality, focuses on what can and cannot be done with a certain type of connection.
- Definition of broadband based only on functionality may make the term overly subjective.
- Broadband defined in terms of functionality, makes the distinction between what is and what is not broadband become less straightforward.








Wireless Broadband Regulatory Insights

- Making spectrum available for affordable wireless broadband services, in frequency spectrum bands designated for mobile/wireless services, is a prerequisite for a good quality wireless broadband master plan.
- A master plan must make spectrum available in harmonised bands which are suitable for the provision of wireless broadband.
- For developing countries, it may not be possible to use an auction as the process for determining the price for spectrum.

Wireless Broadband Regulatory Insights

- Proposals for the pricing of, for example, 3G or 4G spectrum should be consistent with global and regional benchmarks. Some countries may need to use benchmarking studies to determine appropriate prices for 3G or 4G spectrum.
- It is critical that regulators and governments work as partners with network operators, and the ICT sector in general, rather than viewing involvement in the sector as a means of revenue raising.
- Governments and regulators should work together to ensure a reasonable return on investments made in wireless broadband.





Service Delivery Network

- Over all, broadband's importance may be fully realized as it becomes a General Purpose Technology (GPT).
- The concept of GPTs was introduced on a more general basis in the 1990s and includes three key characteristics:
  - Pervasive use in a wide range of sectors
  - Technological dynamism (inherent potential for technical improvements)
  - General productivity gains as GPTs evolve, improve, and spread throughout the economy (Bresnahan and Trajtenberg, 1995).





Broadband Policy

- From a policy perspective, broadband should be viewed more broadly as an enabling ICT platform that can potentially influence the entire economy and thus may act as a general-purpose technology (GPT) that is used as a key input across sectors.
- To capture the full range of potential benefits, policy makers may find it useful to consider broadband as an ecosystem comprising:
  - supply-side considerations (network platforms) and
  - demand-side considerations (e-government initiatives, development of services and applications, promotion of broadband use).





Broadband Policy

- To encourage the diffusion of broadband-enabled innovations throughout the economy, policy makers should consider the absorptive capacity of various sectors, including health, education, energy, and transportation.
- Unless all of these elements—supply, demand, and absorptive capacity—are coordinated, the impact of broadband on the economy as a whole will be constrained.









Broadband KPIs and Measurements

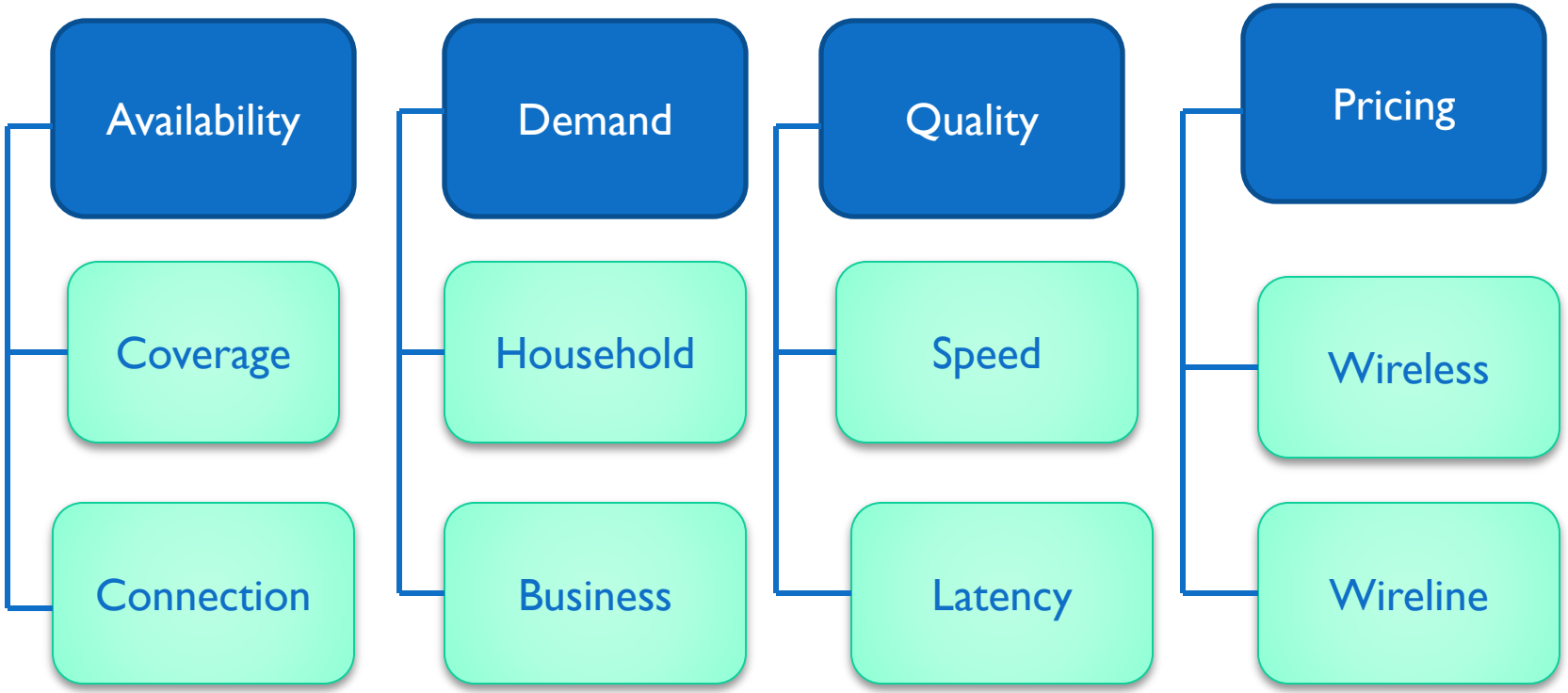
- The Partnership on Measuring ICTs for Development, a coalition of intergovernmental agencies, has produced a methodological manual identifying core ICT statistics including several broadband indicators.
- This manual provides a useful list of key broadband indicators based on definitions with international consensus.

Broadband KPIs and their Measurements

Fig. 1: Categories of Broadband Indicators







Source: Telecommunications Management Group, Inc.

Broadband KPIs and their Measurements

- Attempts to define broadband in terms of speed present certain limitations:
- Broadband speed definitions vary among countries and international organizations, generally ranging from download data transfer rates of at least 256 kbit/s on the low end [ITU 2009, 22).
- Definitions based on speed may not keep pace with technological advances or with the speeds, services, and applications required for the application to function properly.




Broadband KPIs and their Measurements

- What is considered "broadband" today may be regarded as too slow in the future, as more advanced applications technologies are developed.
- Any speed-based definition of broadband will need to be updated over time.
- Third, such definitions by speed may not reflect the speeds realized by end users
- the speeds advertised by commercial broadband providers are quite often much higher than the speeds they provide of set by the government as broadband or vice versa.





What to Measure?

- **Availability (Supply)**
- Availability refers to the ability to access wire-line and wireless broadband networks and services.
- Different modes of providing broadband exist; therefore, different indicators of availability are needed for each of the modes.
- In wire-line systems: availability can be measured by the percentage of households passed.
- The conventional measure in the cable industry that can be extended to fibre and digital subscriber line (DSL) as well.








What to Measure?

- In wireless: the indicator of availability is signal coverage measured terms of population or area.
- ITU has developed a definition for wireless broadband coverage in the form of 3G or 4G network coverage,
- Parallel definitions for fixed wireless, satellite, and wire-line coverage do not exist within the ITU definitions.




What to Measure?

- **Quality :** two performance parameters that must be met by the broadband connection:
  - Latency: the amount of time it takes for a packet to travel between sender and receiver and
  - Speed: high-speed Internet availability, measured Kbps or Mbps
- **Adoption (Demand):** coverage provides theoretical uptake to reflect concrete adoption or usage.
- **Pricing:** "affordable" broadband access is a key factor or goal in broadband initiatives by the governments.

Internet Service QoS

- Internet Services:
  - A variety of audio/video services like Internet radio and IPTV, Internet telephony (VoIP)
  - Blogs, computer games
  - Various ICT applications (e-education, e-government, e-health, e-commerce, etc.).
- The next development in NGN:
  - the emergence of 'Internet of things', which is mainly connected to the development of RFID technology and 'sensor networks'.





Internet Service QoS

- QoS on the Internet is affected by a number of factors, including:
  - Delay
  - Bit Error & Packet loss
  - Speech compression
  - Echo
  - Firewalls





Internet Service QoS

- **Multimedia**
  - The combination of multiple forms of media such as audio, video, text, graphics, fax, and telephony in the communication of information (ITU-T J.148, ITU-T Q.1702)
- **Multimedia services**
  - A telecommunications service that supports the simultaneous use of multiple media types (e.g., voice, data, video) (ITU-T E.417).
- **Streaming (in multimedia services)**
  - Multimedia data (usually combinations of voice, text, video and audio) transferred in a stream of packets that are interpreted and rendered, by a software application as the packets arrive.
  - Streaming a technique for transferring multimedia data.
  - Streaming may or may not be in real time.
- **Download**
  - Transfer of data or programs from a server or host computer to one's own computer or device.




Internet Service QoS

- Different methods can be used to improve QoS.
  - provide the necessary capacity in the backbone and access networks by 'over-provisioning.
  - QoS can also be implemented using one or more of following technologies:
    - Diffserve, ToS, RSVP, etc.
    - Using priority schemes in the IPv6
    - Using appropriate speech codes
    - Buffer size optimization
    - Packet size optimization








Internet Service QoS

- The main deployment of QoS is connected to the introduction and development of IP version 6 (the advanced or next generation IP), which allows for end-to-end QoS provision.
- In the managed IP infrastructures it is possible to provide measurable QoS, but is more difficult in the best effort infrastructures like the Internet;
- In both cases regulatory measures may be necessary.
- An important issue is the facility-based operators' willingness to offer access to QoS provision to non-facility based operators.
- A major issue has been the lack of QoS provision in the wholesale Bit stream access products offered by the PSTN incumbents.

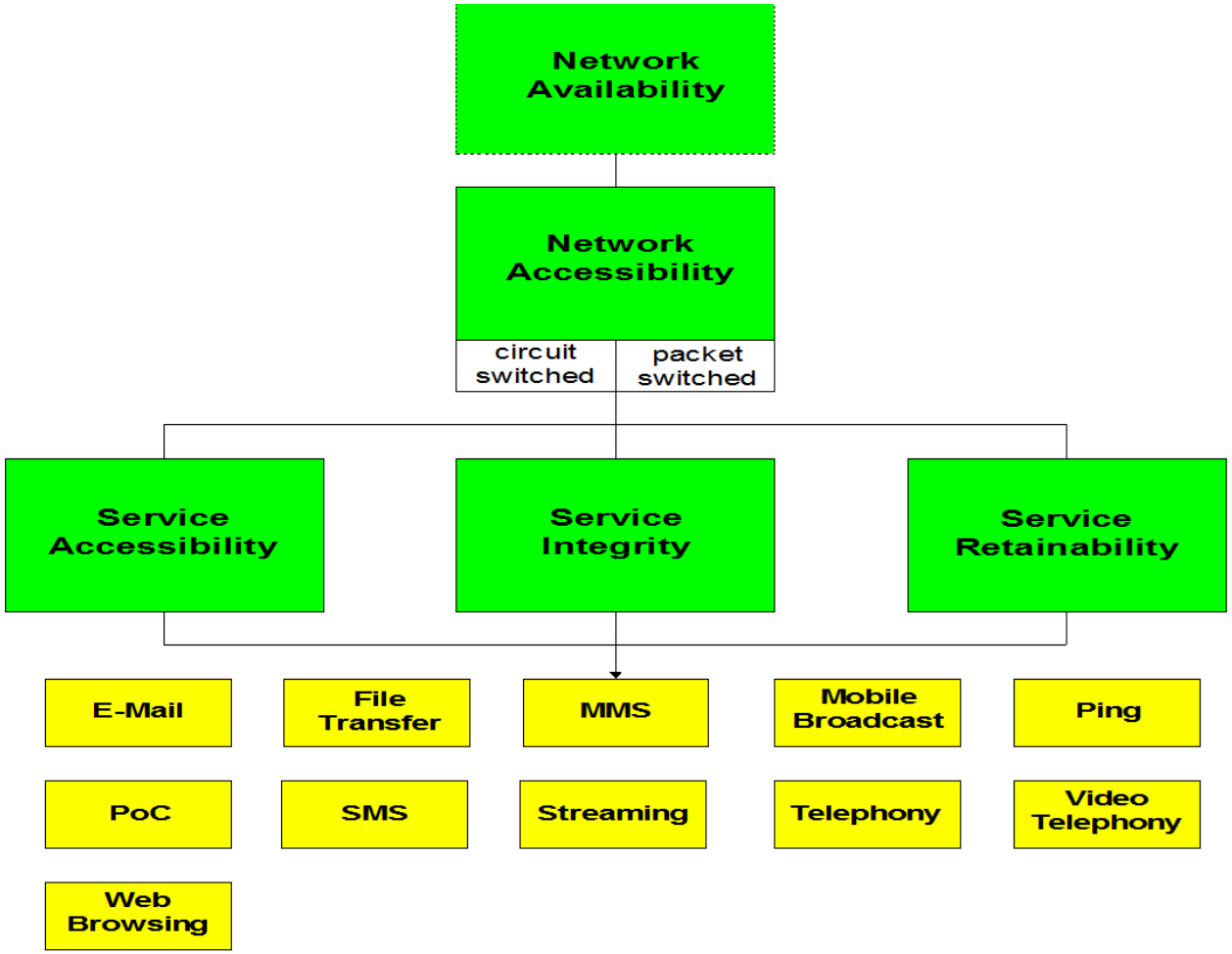
KPIs of service delivery/their Measurement

PSTN Service	QoS Parameter	Measurement
Internet access	Login time	
	Data transmission speed achieved	
	Unsuccessful data transmissions ratio	
	Successful log-in ratio	
	Delay (one-way transmission time)	





QoS Interfaces



INTERCONNECTED NETWORK

INTERCONNECTED NETWORK

- Overview
- Circuit Interconnected
- IP Interconnected

Interconnection

- The physical and logical linking of public communications networks used by the same or a different service provider in order to allow the users of one service provider to communicate with users of another service provider, or to access services provided by another service provider [ITU-T E.800]
- Important both as a consumer issue and for securing fair competition.
- Necessary to ensure that all users can communicate with each other or connect to all the services they demand.





Interconnection

- Ranked by many countries as the single most important regulatory issue with regard to development of real competition in telecom services market
- One of the most complicated areas to regulate because it is technically complicated with a wide range of technical possibilities, and new types products being developed constantly.
- Even small changes in the terms for interconnections may have huge financial consequences for the operators, and it is therefore important that the terms for interconnection are specified in detail.





Circuit Interconnected

- Circuit Switched interconnection products offer connectivity in particular for:
  - voice telephony services
  - other services, such as dial-up Internet services and SMS, services which are all provided through fixed or mobile circuit switched PSTN networks.








Circuit Interconnected

- Switched interconnection products (interconnection of circuit switching services) include whole sale of traffic minutes used by fixed or mobile service providers.
- These service providers take care of all sorts of customer relations such as marketing, billing etc., but leave all network operations to the network operator.
- Origination is used if a customer subscribes to a different operator than the one handling the call (this is for instance the case if pre-coded carrier selection is used).

Circuit Interconnected

- The handling operator must then pay a fee for using the access line.
- Termination is used if the subscriber with whom the call is terminated subscribes to another operator. A fee must also be paid in this case.
- For both origination and termination the charge may depend on at what point in the network the call is handed over to the other operator.
- Here a distinction between interconnection at three different levels in the network is made:
  - Local: Interconnection: at the same local exchange to which the subscriber is connected
  - Single transit: Interconnection to the same transit exchange to which the subscriber is connected.
  - Double transit : Interconnection at any other point in the network.





IP Interconnected

- The most important types of interconnection in packet switched networks relate to Internet interconnection. Internet interconnections are
- interconnections between different public IP networks operated by Internet Service providers (ISPs). Internet interconnection serves a
- purpose similar to that of switched interconnection, as it enables subscribers to the Internet to connect to subscribers (ordinary users or
- content providers) served by other ISPs.
- Internet interconnection agreements are commercial agreements. In contrast to many other types of interconnection agreements, they are usually not subject to regulation and most often their content is confidential. Agreements can therefore take many different forms.





IP Interconnected

- Different types of actors on the market for Internet services:
  - End users: End users include both business and residential customers. These may use the Internet for very different purposes:
  - Use of communication services such as e-mail, VoIP and instant messaging.
  - Information retrieval
  - Provision of information (may be financed through commercials or user charges)
  - Internet Service Providers (ISPs) providing end user access to the Internet.
  - Internet Backbone Providers (IBPs) providing connectivity between ISPs and to other IBPs.







IP Interconnected

- Some companies act both as an ISP and an IBP.
- IBPs can be categorized into different layers according to their network coverage.
- Only the largest IBPs provide world-wide connectivity, while others provide national or regional connectivity.
- In principle there are two different types of agreements, peering and transit: peering and transit

Peering

- Peering may be defined as: 'An interconnection of two public networks that provide connectivity to hosts whose routes are on the global Internet on a settlement-free basis that allows customers of one network to exchange traffic to customers directly on the second ISP's network.'
- Peering was the kind of settlement used in the early days of the Internet, when interconnection mainly involved interconnection of research and education networks.
- The most important aspect of this definition is that no settlements are made between the two networks.
- Peering agreements will usually be made between two ISPs of similar size with regard to network infrastructure and customer base. In this case both ISPs will have a mutual interest in establishing interconnection of their networks, and neither of them is able to impose a fee on the other.




Peering

- Another characteristic of peering is that both ISPs will accept the receipt of traffic terminating within their own network only. A peering ISP will not allow traffic from another ISP to transit traffic to a third party through his network.
- Peering arrangements can either be done on a bilateral basis (private peering) or by using a common Network Access Point (NAP), also called an Internet exchange point (an IX), where a number of service providers exchange their traffic on a peering basis (public peering).
- Such a network access point may be established by national or regional ISPs in co-operation or by the public, who in this way wants to improve connectivity.








Transit

- Transit agreements are made between an ISP and an Internet Backbone Provider (IBP). Internet-backbone providers are characterized by having extensive network facilities interconnecting with ISP as well as other IBPs.
- A transit agreement allows ISPs to extend their reach into regions not covered by their own infrastructure or by their peering partners.
- In contrast to peering agreements, transit agreements involve some kind of payment from the minor to the major provider.
- On the other hand, the major provider guarantees delivery of packets not only to its own network, but also to all other parts of the global Internet.

Transit

- Such agreements usually include a service level agreement (SLA) specifying capacity and other service parameters.
- A wide range of settlement schemes can be defined for such agreements, but the amount of settlements will depend on the level of service specified in the SLA, amongst others.
- In addition to Internet interconnection, there is a need for interconnection of other types of packet switched networks.
- These networks are often used by Internet providers as bearer services supporting transmission in IP networks, but such connections are also used by other large-scale users of data transmission.




Internet exchange points (IXPs)

- National or regional Internet exchange points (IXPs),
- The physical infrastructure where Internet service providers (ISPs) exchange Internet traffic between their networks, plays a crucial role in ensuring more efficient and cost-effective Internet interconnection .
- Similarly, as the transition toward IP-based NGNs proceeds, questions will arise regarding the manner and terms under which IP-based interconnection will take place between different types of networks and at different functional levels of the network.
- Relevant are issues relating to future wholesale charging mechanisms that may apply to converged broadband networks.
- The current trends and expected regulatory developments need to be addressed.








End of Session

Q & A