BcN Traffic Engineering Technology

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Contents

- BcN (NGN)
- Introduction to TE
- QoS review
- QoS apportionment
- QoS support techniques
- QoS parameter mapping
- Traffic measurement

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BcN 정의

- **BcN**
  - 통신, 방송, 인터넷이 융합된 품질보장형 광대역 멀티미디어 서비스를 언제 어디서나 끊김없이 안전하게 이용할 수 있는 차세대 통합 네트워크
- **Requirement**
  - 품질보장(QoS), 보안(Security), IPv6, Open API

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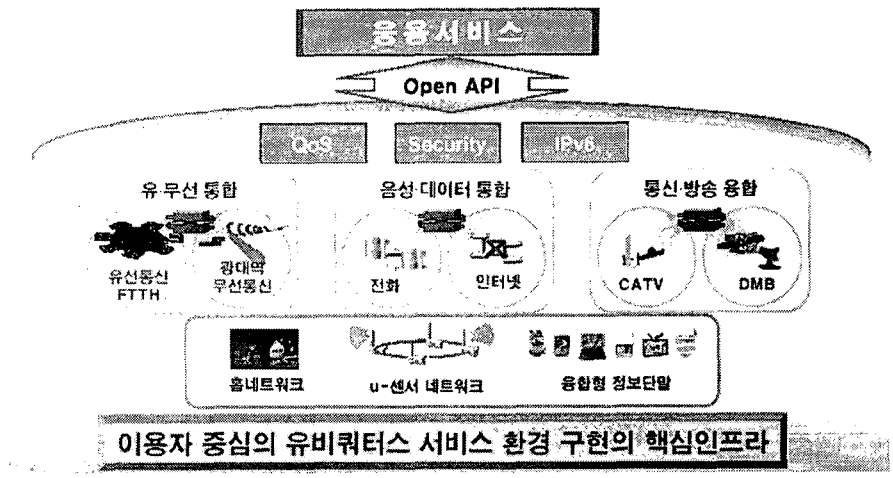
BcN 개념



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BcN 서비스

- 융합형 서비스
  - 음성-데이터 통합 서비스
    - 영상전화, 영상회의 서비스, VoIP, MMoIP
  - 유무선 통합 서비스
    - One phone, 웹 검색, e-mail, 온라인 증권, 게임, VoD
  - 통신-방송 융합 서비스
    - DMB, T-commerce, T-Gov, VoD
- **QoS/security** 서비스
  - 품질보장형 VoD, 홈뱅킹, 보안강화형 VPN, 전자상거래
- 홈네트워크 서비스
  - 홈 멀티미디어, 홈 오토메이션, 지능형 서비스 로봇
- 유비쿼터스 서비스
  - 텔레매틱스, u-commerce

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NGN Definition

- **A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies**
  - In NGN, service-related functions are independent from underlying transport-related technologies
  - Offers unrestricted access by users to different service providers
  - Supports generalized mobility which will allow consistent and ubiquitous provision of services to users

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NGN Characteristics - 1

- **Packet-based transfer**
- **Separation of control functions among bearer capabilities, call/session, and application/ service**
- **Decoupling of service provision from network and provision of open interfaces**
- **Support for a wide range of services, applications and mechanisms**
  - Including real time/ streaming/ non-real time services and multi-media
- **Broadband capabilities with end-to-end QoS and transparency**
- **Interworking with legacy networks via open interfaces**
- **Generalized mobility**

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NGN Characteristics - 2

- **Unrestricted access by users to different service providers**
- **A variety of identification schemes for routing in IP networks**
- **Unified service characteristics for the same service as perceived by the user**
- **Converged services between Fixed/Mobile**
- **Compliant with all regulatory requirements**
  - For example, concerning emergency communications and security/privacy, etc.

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NGN Capabilities

- **Basic network capabilities**
  - Switching and routing, routing/address resolution, IP bearer control, client/server address management, client/server registration, charging, interworking, etc.
- **Mobility**
  - Service, terminal, user mobility
- **Identification and authentication**
- **Location management**
- **Presence**
  - Capability to collect, collate, track, and provide presence information
  - Support services such as communication services (IM, MMS, etc.)
- **Group management (CUG/VPN)**
- **Session control**
- **Service subscription (registration) management**
- **User and terminal profile management**
- **Resource and QoS management**
- **Security support**
- **Service creation and customization**

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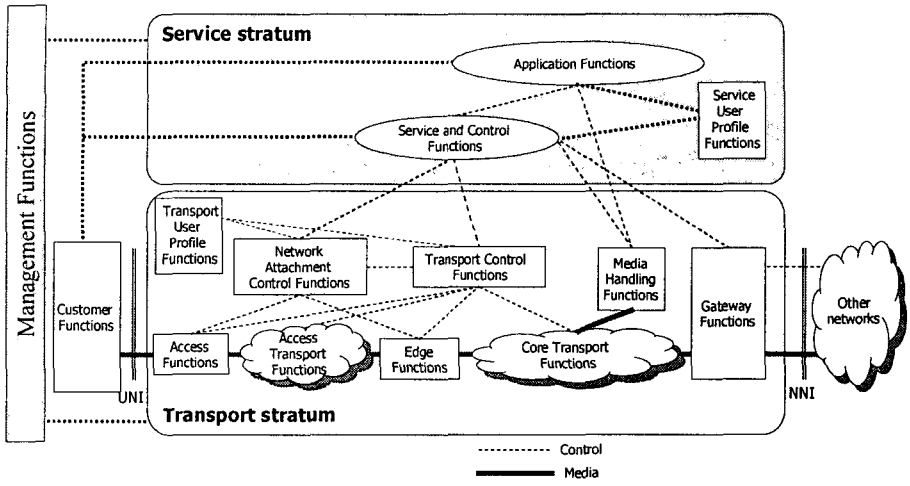
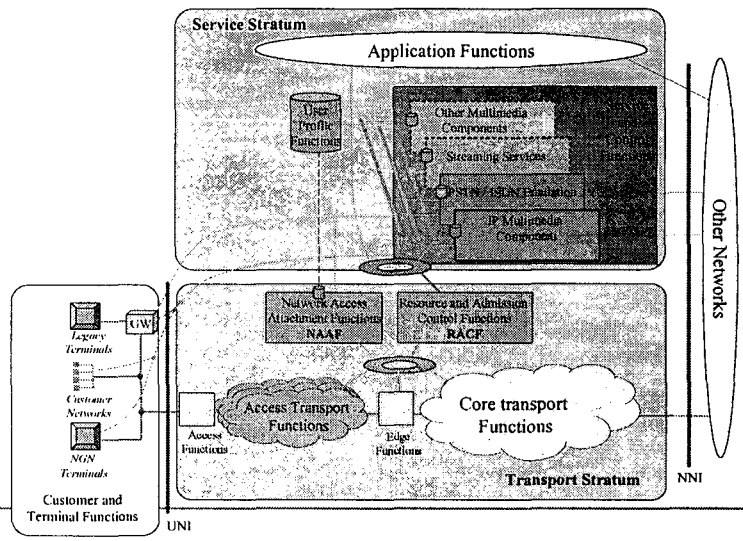
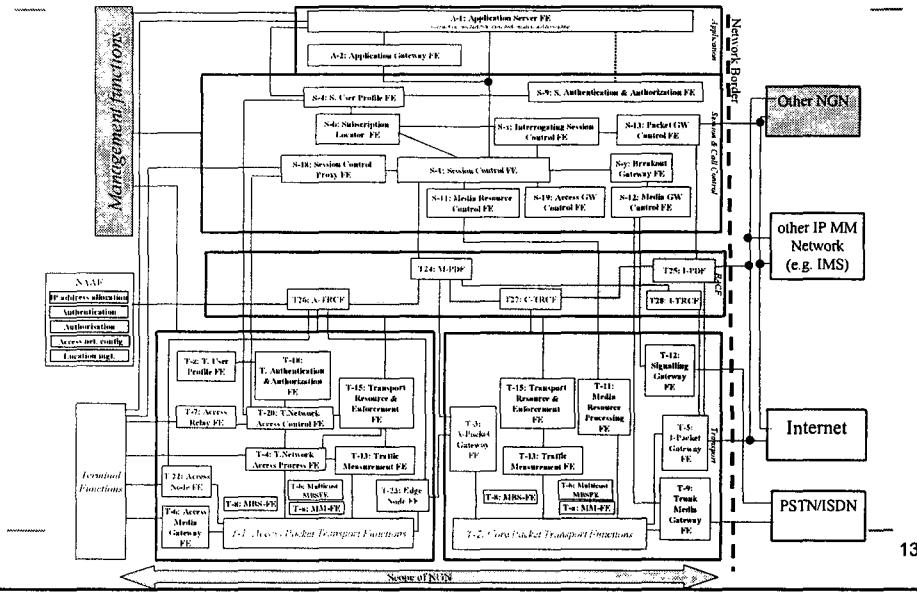
NGN Architecture



NGN Functional Entities



NGN Functional Architecture



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Traffic Engineering

- **Definition**
  - Performance evaluation & optimization of operational IP networks
- **Goal of Internet TE**
  - To facilitate efficient and reliable network operations while simultaneously optimizing network resource utilization and traffic performance
- **Motivation**
  - TE has become an indispensable function in many large AS because of the high cost of network assets and the commercial and competitive nature of the Internet

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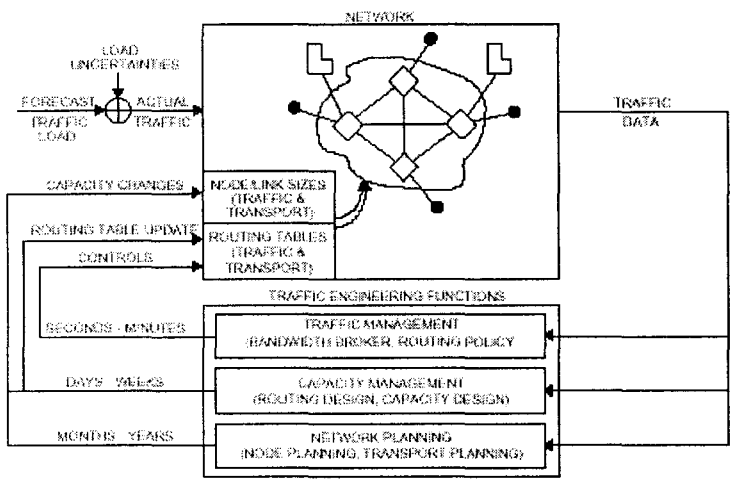
TE Framework



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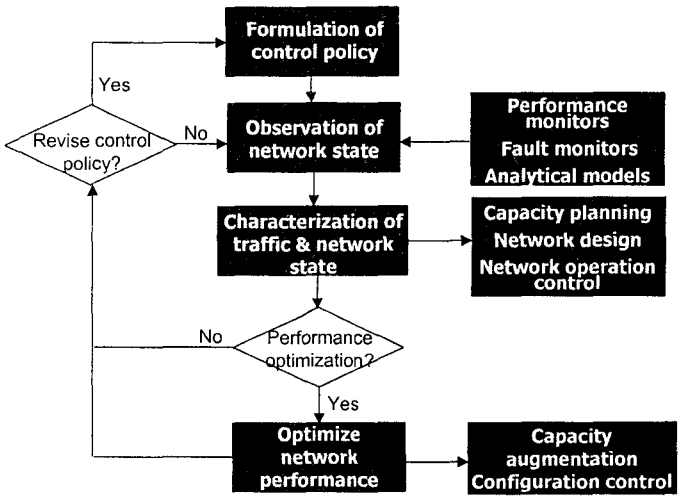
TE Process Model

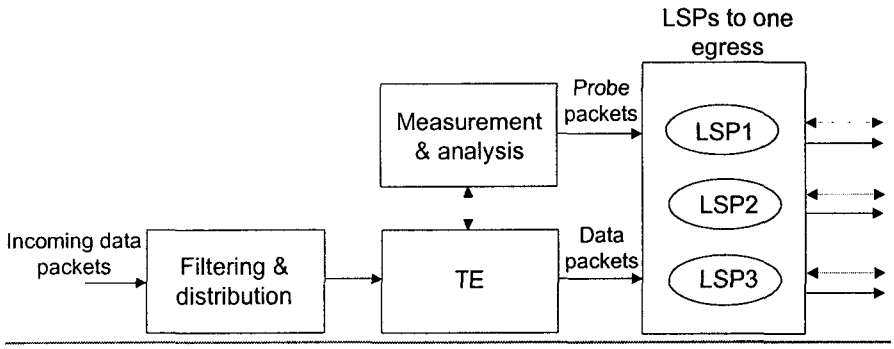


Intra Domain TE

- **Resource optimization**
  - Redirect paths of aggregated flows away from over-utilized resources within a network
  - Constraint-based Shortest Path First
  - Load balancing
- **QoS guarantees**
  - Packet classification, marking, policing, shaping, queue management, scheduling, admission control
- **Fast recovery**
  - Guarantee traffic recovery on the order of tens of ms in case of network element failure
  - Fast reroute (local protection): one-to-one, and facility backup

Load Balancing

- **State-dependent, adaptive load-balancing algorithm**
  - Measure delay or packet loss using probe packets
  - Adapt loads of multiple LSPs to network state
  - Distribute loads to each LSP to minimize congestion



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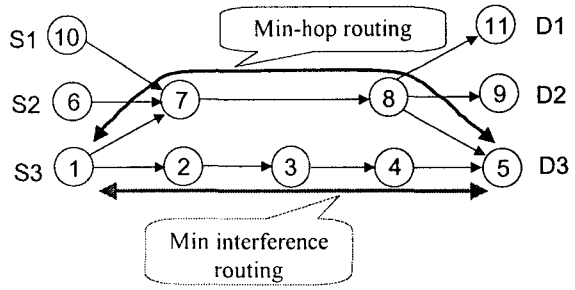
Constrain-based Routing

- **Assume**
  - There are 3 potential pairs (S1, D1), (S2,D2), (S3, D3)
  - All links have a residual bandwidth of 1 unit
  - A new request for a LSP b/w S3 and D3
- **Min interference routing**



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Recovery Schemes

Recovery Schemes

Protection

Backup resources (routes and wavelengths) are *precomputed and reserved in advance*

- Guaranteed recovery
- Shorter recovery time
- Backup resources "wasted" (unless alloted to preemptable traffic)

⇒ Suitable for optical layer (with Lambda Routing)

Restoration

Backup resources are *dynamically discovered after failure occurs*

- No guarantee on recovery (backup resources may not be found)
- Longer recovery time

⇒ Suitable for Layer 3 (IP packet switching)

Ring Protection

- APS (Automatic Protection S/W)
- SHR (Self-Healing Rings)

Mesh Protection

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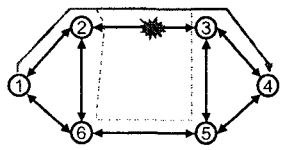
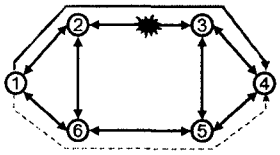
Restoration

Link Restoration



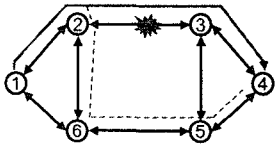
Resources to back up "link (2,3)" failure (not reserved)

Path Restoration



Backup lightpath (not reserved)

Subpath Restoration



Backup lightpath (not reserved)

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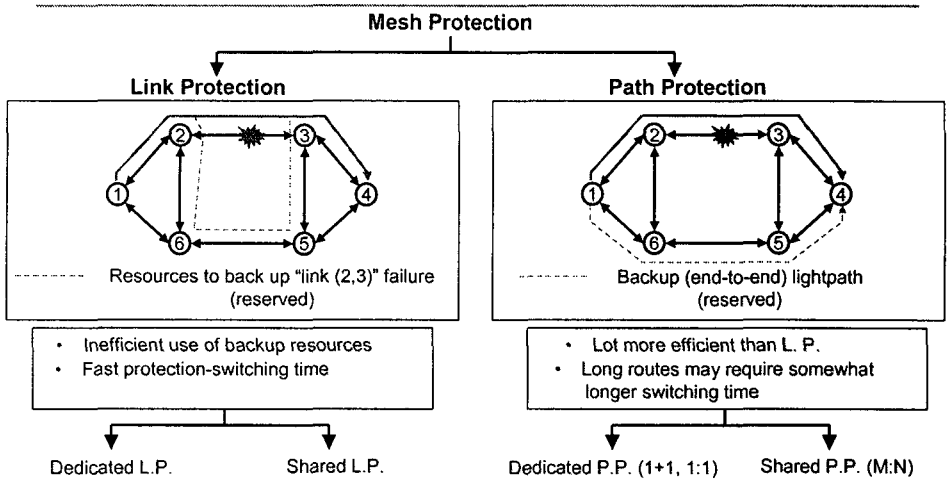
Mesh Protection



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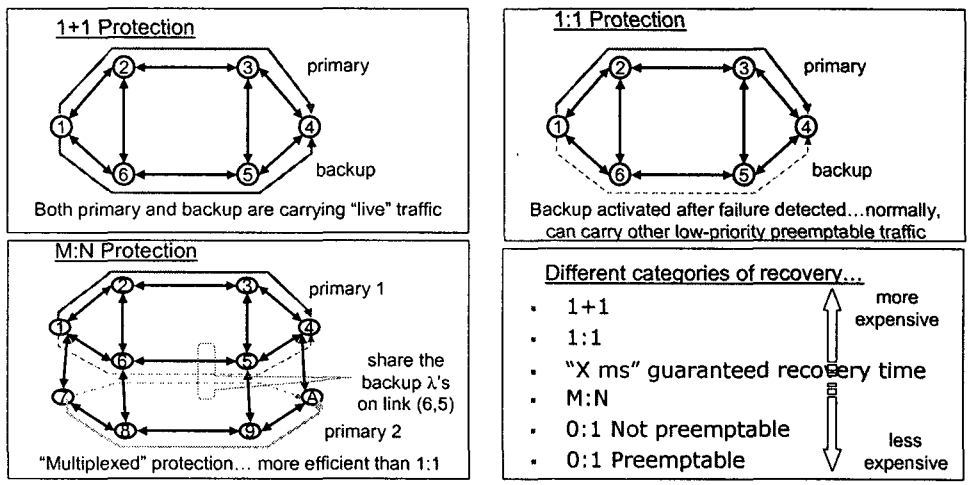
Path Protection



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Inter Domain TE

- **MPLS-TE mechanisms are currently limited to a single IGP area**
- **Many operators may migrate to a multi-area environment**
- **BcN must consider multi domains including heterogeneous networks**
- **Inter domain TE**
  - Perform inter-area resource optimization
  - Provide inter-area QoS guarantees for traffic between edge nodes located in different areas
  - Provide fast recovery across areas, to protect inter-area traffic in case of link or node failure, including ABR node failures

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Inter Domain TE Issues

- **Seamless interoperability with current intra-area TE mechanisms**
- **Inter-area TE-LSP signaling**
- **Path optimality**
  - Provide the capability to dynamically compute an optimal path satisfying a set of specified constraints across multiple domains
- **Inter-Area MPLS-TE Routing**
- **Support of diversely routed inter-area TE LSPs**
- **Fast recovery of inter-area TE LSP**
- **DiffServ-TE support**

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Terminologies

- QoS in ITU-T E.800 ('94.08)
  - **Quality of Service** is a collective effect of service performances which determine the degree of satisfaction of a user of the service
- NP in ITU-T I.350 ('93.03)
  - **Network Performance** is measured in terms of parameters which are meaningful to the network provider and are used for the purposes of system design, configuration, operation and maintenance
- QoE in ITU-T SG12 (2004)
  - **Quality of Experience** is the overall acceptability of an application or service, as perceived subjectively by the end-user

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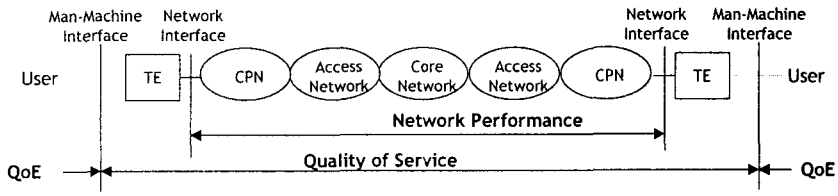
QoS/NP/QoE on NGN

(출처 : ITU-T Focus Group on NGN, TR-NGN.QoS)



* QoS/NP는 정량화가 가능한 파라미터로 정의됨

Quality of Experience	Quality of Service	Network Performance
User oriented		Provider oriented
User behavior attribute	Service attribute	Connection/Flow element attribute
Focus on user-expected effects	Focus on user-observable effects	Focus on planning, development (design), operations and maintenance
User subject	Between (at) service access points	End-to-end or network elements capabilities

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References in ITU Recommendations

- **QoS related ITU-T Recommendations**
  - Led by ITU-T SG 12
  - G.1000 : Communications quality of service: A framework and definitions
  - G.1010 : End-user multimedia QoS categories
- **Network Performance related ITU-T Recommendations**
  - I.350 : General aspects of quality of service and network performance in digital networks, including ISDNs
  - I.356 : B-ISDN ATM layer cell transfer performance
  - Y.1541 : Network performance objectives for IP-based services
  - Y.1561 : Performance and availability parameters for MPLS networks
- **QoE related ITU-T Recommendations**
  - P.800 : Methods for subject determination of transmission quality
  - G.114 : One-way transmission time
  - G.107 : The E-model, a computational model for use in transmission planning
  - G.834 : Methodology for the derivation of equipment impairment factors from instrumental models
  - 최근 ITU-T SG12에서는 Non-voice E-model에 대한 연구를 시작

General QoS Model (1)

- **Intrinsic QoS**
  - Service features stemming from technical aspects
  - Determined by a transport network design and provisioning of network access, terminations and connections
  - Achieved by an appropriate selection of transport protocols, QoS assurance mechanisms, related parameters
  - Evaluated by the comparison of measured and expected performance characteristics

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General QoS Model (2)

- **Perceived QoS**
  - Reflect customer's experience of using a particular service
  - Influenced by customer's expectations compared to observed service performance
  - QoS with the same intrinsic features may be perceived differently by various customers
- **Assessed QoS**
  - Starts to be seen when the customer decides whether to continue using the service or not
  - Depends on perceived quality, service price, response of the provider to complaints and problem

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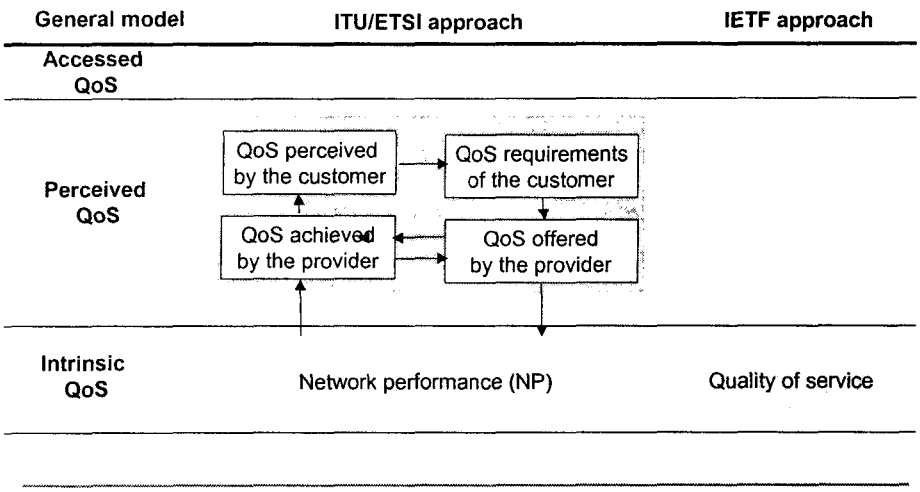
General QoS Models



이용자 품질 요구사항 정량화

- **Application QoS (G.1010)**
  - Application별 품질 기준을 명시 (Network QoS + CPN/CPE QoS)
  - IP-based Network에 대한 고려로, 상대적 (PSTN/ATM) loose한 기준 규정

어플리케이션	Information Delay	Information Delay Variation	Information Loss
VoD	10초 이내	-	1% 미만
IP-TV	10초 이내	-	1% 미만
IP-TV (interactive)	2초 이내	-	0%
Game on Demand	200ms 이내	-	0%
VoIP	150ms 이내	1ms 이내	3% 미만
Video Phone	150ms 이내	80ms 이내의 lip-sync율	1%

- **Application QoS Classes (TR-NGN.QoS)**
  - 다양한 어플리케이션의 존재
  - Expense 기반 Policy (VoIP/VoD : High QoS/Low QoS)

통신망 구현 목표로 번역/변환 -1

- 네트웍 특성에 적합한 **Network Performance**로 번역/변환
  - IP 통신망: Y.1541

Performance Parameter	Nature of Network Performance Objective	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
IPTD	Upper bound on the mean IPTD	100 ms	400 ms	100 ms	400 ms	1 s	U	100 ms	400 ms
IPDV	Upper bound on the $1\text{-}10^{-3}$ quantile of IPTD minus the minimum IPTD	50 ms	50 ms	U	U	U	U	50 ms	50 ms
IPLR	Upper bound on the packet loss probability	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	U	$1*10^{-5}$	$1*10^{-5}$
IPER	Upper bound	$1*10^{-4}$					U	$1*10^{-6}$	$1*10^{-6}$

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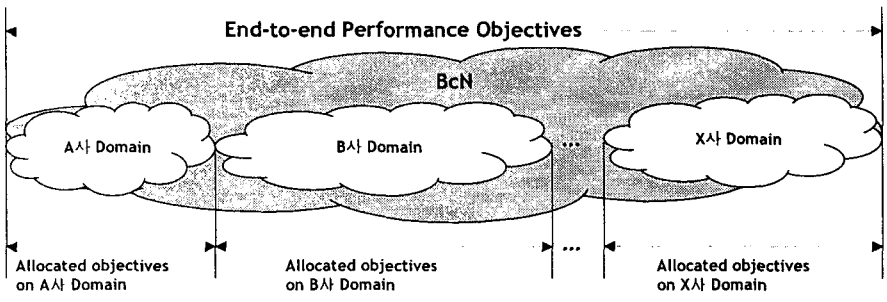
통신망 구현 목표로 번역/변환 - 2

- 이용자 품질 요구사항 : 네트워크 성능 + 단말 성능 + 이용자의 주관적 인지
- 어플리케이션 성능 : 네트워크 성능 + 단말 성능
- 네트워크 성능 (거리 & 노드 수에 반비례) : 국내구간 + 국제구간



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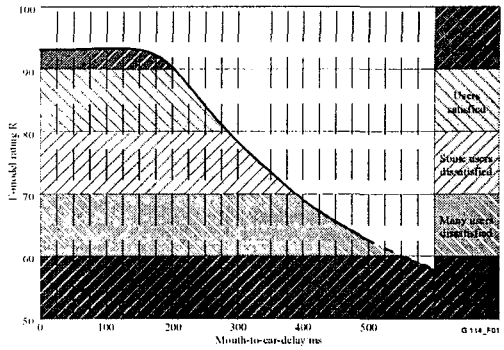
품질 요구사항의 구현 수준 확인

- **R-Value**
  - Mouth-to-ear 구간에서 이용자가 느끼는 음성품질 등급을 계산하는 척도



  - 현재 Voice에 대한 표준만 존재, ITU-T SG12에서 Non-voice R value/E model 개발 시작 (2005.02.)

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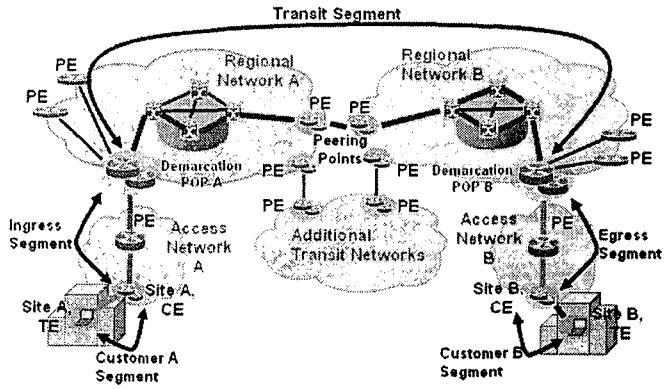
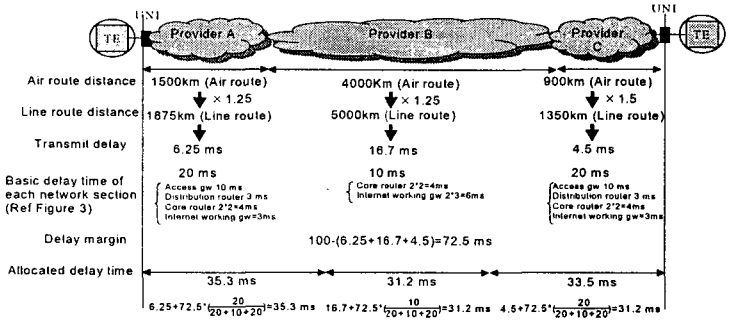
Segments for QoS Apportionment



Example

- Based on Access Network Type
- Based on Core Network Scale (Distance)



[Source : ITU-T TR-APO]

G.FEPO - Summary of Apportionment Approaches

Approach	Description	Information required at each segment	Pros	Cons
Static (simplest/least flexible) no information is required to be shared among segments	A fixed number of segments is assumed. Allocation is formulaic among User, Access, and Transit segments	Information required is a)type of link. b)traffic service class and, c)transit distance	No information is required to be shared among segments. Providers may re-allocate among their User, Access and Transit Segments	Over-engineered when number of segments is less than number assumed. Paths with more than assumed number of segments are not covered. No negotiation. Works best with static routing, which is not common anymore.
Pseudo-static - some information is required to be shared among segments	The exact number of transit providers is determined Impairment allocation is formulaic among User, Access, and Transit segments	Information required is a) type of link. b) traffic service class and, c) transit distance d) destination address e) BGP tables	Impairment allocation may be efficient and scalable.	Signaling among providers required to determine the number of transit providers in each traffic path, e.g. from BGP number of AS's. Negotiation not supported. Works best with static routing.
Signaled (least simple but most flexible) - some info. is required to be shared among segments and possibly with users	Exact number and sub-type of all segments may be known e.g. if User segment is wireless or wireline. apportionment may be negotiated among segments and with Users	Information required is a)type of link. b)traffic service class c)destination address d)BGP tables, or other means to determine path(s) at operator-level. e)Network edge-edge performance information Additional information required may include a)transit distance	Negotiation is supported allowing highly flexible apportionment among segments. Transit distance may not be required Able to address cases where objective can not be met by user for relaxed objective Consistent with proposed direction of methods automated by QoS Signaling (e.g. RSVP/NSIS)	Signaling required to apportion amounts to each segment, and to negotiate with user when the requested objective cannot be met. Performance and routing info. must be signaled to determine identities of transit providers in each path (e.g. from BGP, # of AS's) and their performance. However, there are alternative ways to determine path, and some providers give performance info in real-time.

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QoS Supports in Internet

- **RSVP**
  - Signaling protocol supporting IntServ along the path to set up per-flow QoS
  - Mechanism for configuring traffic handling mechanisms in network devices for per-flow-based traffic
- **DiffServ**
  - Traffic handling mechanism for aggregate traffic to overcome scalability problems of per-flow QoS management
  - DSCP, packet classification, PHB, packet marking, packet policing
- **MPLS**
  - Mechanism for engineering network traffic patterns that is not subject to the limitations of different routing protocols, transport layers, addressing
  - Increase the efficiency of data throughput by optimizing packet processing overhead

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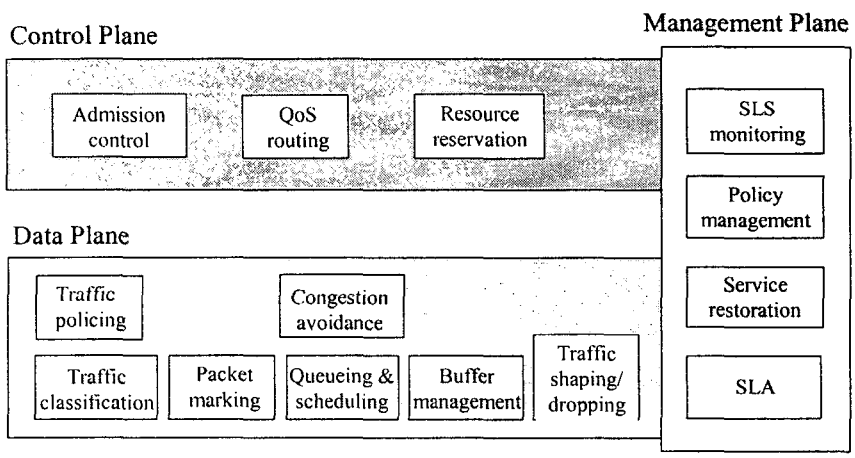
QoS Building Blocks



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Issues for DiffServ-based Framework (1)

- **DiffServ fails to be the solution for end-to-end QoS provisioning**
  - Only effective in the DiffServ domain
  - Combination of some QoS mechanisms required
- **Service definition for bursty traffic**
  - Deterministic definition – inefficient
  - Statistical definition – difficult to understand, measure, and verify
  - Require common agreement among service providers and users
- **Dynamic service creation and configuration tool**
  - Not feasible to manually configure a large number of devices in a consistent way
  - Allow an operator to define services in an abstract way and have an automatic mapping into the configuration of network devices

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Issues for DiffServ-based Framework (2)

- **TE tool**
  - DiffServ basically specifies PHB locally on a router/link
  - Important for a provider to manage the resources globally within a network backbone
- **Dynamic service invocation**
  - Allocation of bandwidth on demand can be of great interest for applications like video communication, videoconferencing, where a large amount of resources is needed for a limited period time
- **SLS monitoring**
  - Identify QoS measurement metrics, measurement methods, monitoring points, monitoring domains
  - Require unification of automated measurement configuration, reporting, and analysis over heterogeneous measurement tools

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Issues for DiffServ-based Framework (3)

- **Interdomain QoS**
  - It should be possible to receive QoS across different domains
  - QoS-related functions at the interface between different providers must be clarified
  - Combination of single domain QoS levels into the whole end-to-end QoS requied
- **QoS signaling**
  - Convey application performance requirements, reserve resources, discover QoS routes
  - In band/out of band
  - Path-coupled/path-decoupled
  - End-to-end QoS signaling support must be provided

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QoS Supports in Enterprise Networks

- **WAN QoS mechanisms**
  - DiffServ
  - MPLS
- **LAN QoS mechanisms**
  - Switched full-duplex Ethernet (L2 switch)
  - IEEE 802.1D user priorities
  - Subnet bandwidth manager signaling protocol
  - RSVP E2E
- **LAN-WAN interworking**
  - IntServ over DiffServ
- **Service and policy infrastructure**
  - SLS, DiffServ implementations
  - CAC for VOIP

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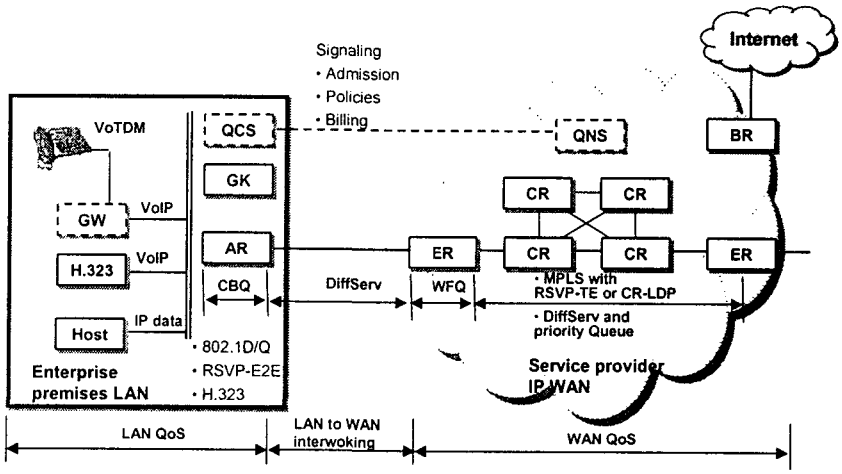
QoS Support in Enterprise Networks



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Schedulers

- **WFQ (Weighted Fair Queuing)**
  - Packet service in sequence of virtual finish time
  - Only guarantee worst case delay bound
  - High complexity
- **EDD (Earliest Due Date)**
  - Individual packet level treatment for delay guarantee
  - Unrealistic scheduling
- **ADRR (Absolute Deficit Round Robin)**
  - Absolute end-to-end delay guarantee
  - Prevent unnecessary resource pre-emption
  - Increase of network throughput
  - Low complexity

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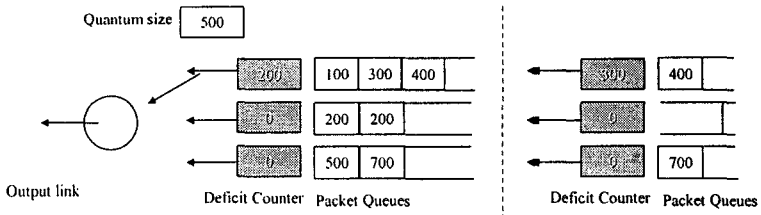
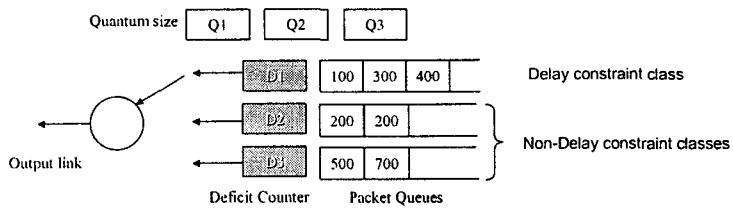
DRR Scheme

- Deficit Round Robin
- Assign a Quantum to Each Queue
- Service the queues in a round robin way when the sum of the packet sizes is greater than Deficit Counter (DC) of the queue
- DC = Quantum + previous DC



ADRR Scheme

- Absolute Deficit Round Robin
- Initial Quantum
  - Σ Initial Quantum = Constant
- Traffic Classes
  - Delay-Constraint class(es), Non-Delay-Constraint class(es)



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- Traffic measurement

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QoS Class in IP

Performance Parameter	Nature of Network Performance Objective	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
IPTD	Upper bound on the mean IPTD	100 ms	400 ms	100 ms	400 ms	1 s	U	100 ms	400 ms
IPDV	Upper bound on the $1-10^{-3}$ quantile of IPTD minus the minimum IPTD	50 ms	50 ms	U	U	U	U	50 ms	50 ms
IPLR	Upper bound on the packet loss probability	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	U	$1*10^{-5}$	$1*10^{-5}$
IPER	Upper bound	$1*10^{-4}$					U	$1*10^{-6}$	$1*10^{-6}$

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QoS Class in DiffServ & IntServ

- **Differentiated Service**
  - EF (Expedited Forwarding)
  - AF (Assured Forwarding)
    - 4 classes
    - 3 levels of drop precedence of each 4 class
    - One-to-one, many-to-one mapping
  - BE (Best Efforts)
- **Integrated Service**
  - Guaranteed Service
  - Controlled Load
  - Best Effort

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QoS Class in UMTS

- **UMTS QoS Classes**
  - Conversational Class: the most demanding QoS class, Preserve time relation (variation) between information entities of the stream Conversational pattern (stringent and low delay).
    - Example: Voice, Video conference
    - real time traffic
  - Streaming Class: Preserve time relation (variation) between information entities of the stream.
    - Example: Streaming Video
    - time relation between information entities within a flow must be preserved.
  - Interactive Class: Request response pattern.
    - Example: Web browsing
    - human to machine interaction
  - Background Class: Destination is not expecting the data within a certain time
    - Example: Email.
    - Machine to machine interaction

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UMTS QoS Class Parameters

Traffic class	Conversational class	Streaming class	Interactive class	Background class
Maximum bitrate (kbps)	< 2 048	< 2 048	< 2 048 - overhead	< 2 048 - overhead
Delivery order	Yes/No	Yes/No	Yes/No	Yes/No
Maximum SDU size (octets)	<= 1 502 with PPP <= 1500 otherwise	<= 1 502 with PPP <= 1500 otherwise	<= 1 502 with PPP <= 1500 otherwise	<= 1 502 with PPP <= 1500 otherwise
SDU format information	List of possible SDU sizes	List of possible SDU sizes		
Delivery of erroneous SDUs	Yes/No/-	Yes/No/-	Yes/No/-	Yes/No/-
Residual BER	$5*10^{-2}$, 10^{-2}, $5*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	$5*10^{-2}$, 10^{-2}, $5*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}	$4*10^{-3}$, 10^{-3}, $6*10^{-8}$	$4*10^{-3}$, 10^{-3}, $6*10^{-8}$
SDU error ratio	10^{-1}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	10^{-1}, 10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}	10^{-3}, 10^{-4}, 10^{-6}	10^{-3}, 10^{-4}, 10^{-6}
Transfer delay (ms)	100 – maximum value	250 – maximum value		
Guaranteed bit rate (kbps)	< 2 048	< 2 048		
Traffic handling priority			1,2,3	
Allocation/Retention priority	1,2,3	1,2,3	1,2,3	1,2,3

QoS Class in WLAN

TABLE II. 802.1D TRAFFIC TYPE [4]

User Priority	Acronym	Traffic Type
1	BK	Background
2	-	Spare
0 (Default)	BE	Best Effort
3	EE	Excellent Effort
4	CL	Controlled Load
5	VI	Video < 100 ms latency and jitter
6	VO	Voice < 10 ms latency and jitter
7	NC	Network Control

TABLE I TCID TO ACCESS CATEGORY MAPPINGS

TCID	Priority	Access Category	Traffic Type
1	1	0	Best Effort
2	2	0	Best Effort
0	0	0	Best Effort
3	3	1	Video Probe
4	4	2	Video
5	5	2	Video
6	6	3	Voice
7	7	3	Voice

QoS in 3GPP IMS

QoS class	UMTS Traffic Class	Traffic Handling Priority
A	Conversational	N/A
B	Streaming	N/A
C	Interactive	
D		2
E		3
F	Background	N/A
NOTE: QoS class represents the highest class that can be used for the bearer.		

출처: 3GPP 29.207v6

- "Authorised QoS" information for the PDP context into authorised UMTS QoS information
- GGSN shall perform the proper mapping between the IP QoS information and the UMTS QoS information
- The GGSN shall derive the highest allowed UMTS Traffic class for the PDP context from the QoS class in the "Authorized QoS" according to table

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Class Group Mapping (access)

TCID	Access Category	Traffic Type
1	0	Best effort
2	0	Best effort
0	0	Best effort
3	1	Video probe
4	2	Video
5	2	Video
6	3	Voice
7	4	Voice

User priority	Acronym	Traffic Type
1	BK	Background
2	-	Spare
0 (Default)	BE	Best effort
3	EE	Excellent effort
4	CL	Controlled Load
5	VI	Video<100ms latency and jitter
6	VO	Voice<10ms latency and jitter
7	NC	Network Control

Traffic class(AC)	Example	DSCP	TCIP
Class 1	VoIP	(101)xxx for EF	7
Class 2	Video Streaming	(100)xxx for AF4x	5
Class 3	Signaling bearer	(010)xxx for AF2x	3
Class 4	Normal Data (e-mail, Web)	(000)000 Default best effort	1

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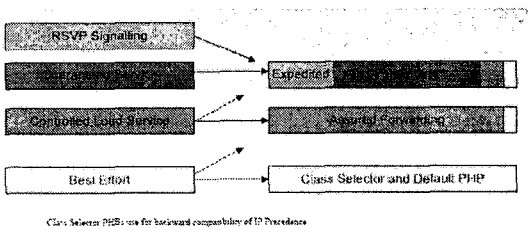
Class Group Mapping (backbone)

IntServ	ATM
Guaranteed Service	CBR or rtVBR
Controlled Load	NrtVBR or ABR
Best Effort	UBR or ABR

IntServ	DiffServ
Guaranteed Service	EF
Controlled Load	Assured (High priority)
Best Effort	Assured (low priority)



UMTS	DiffServ
Network management	Network control
Conversational	EF
Streaming	AF11, AF12, AF13
Interactive	AF22,AF22,AF23
Background	BE

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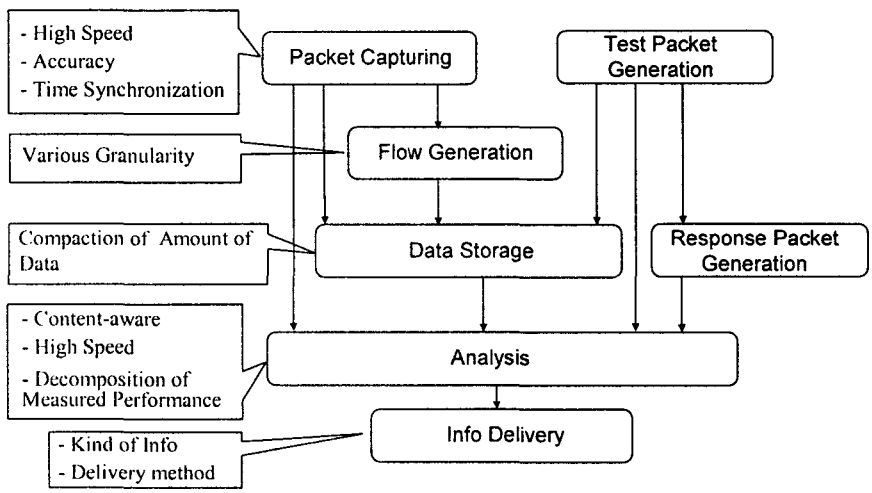
통신망 환경 변화

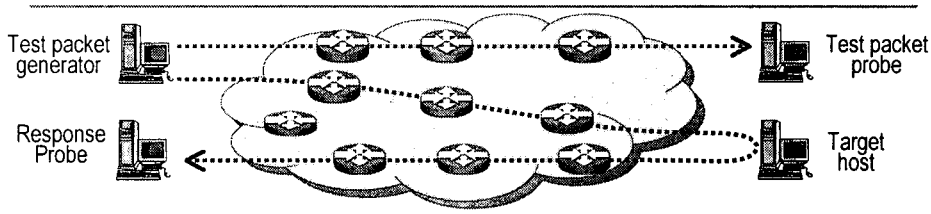
- 통신망
  - 서비스별 개별망 → 통합망
  - 링크 속도: 수십~수백 Mbps → 수 Gbps
  - 액세스망의 다양화 : LAN, xDSL, PON, WLAN, 2G/3G 이동망
- 트래픽
  - 규모: exponential growth (> 수십 Tbps)
  - 형태: P2P, multicast, dynamic session, streaming
- 서비스
  - Web service, online game, home shopping, network storage, VOD, VOIP, FMC service

→ 새로운 측정 패러다임 구축 및 새로운 측정 기술 개발을 요구

Measurement Process



Active Measurement (1)



- **Send test traffic into network**
  1) Generate test packets periodically or on-demand
  2) Measure performance of test packets or responses
  3) Take the statistics
- **Impose extra traffic on network and distort its behavior in the process**
- **Test packet can be blocked by firewall**
- **Mainly used to monitor network performance**

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Active Measurement (2)

- **ICMP-based method**
  - Diagnose network problems
  - Availability / Round-trip delay / Round-trip packet loss
- **TCP-based method**
  - One-way bandwidth / Round trip bandwidth
  - Bulk transfer rate
- **UDP-based method**
  - One-way packet loss / Round trip bandwidth

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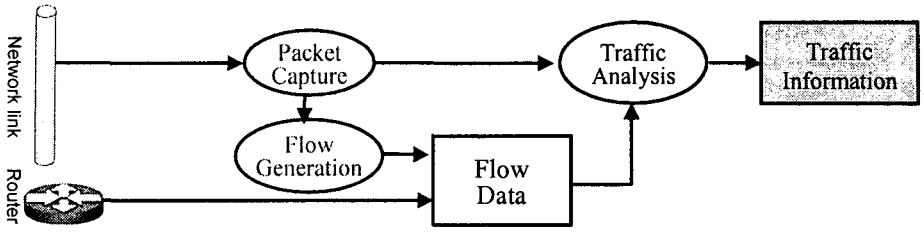
Passive Measurement



- Observe network traffic
  - Collect packets from a link or network flow from a router
  - Perform analysis on captured packets for various purposes
- Network device performance degrades by mirroring or flow export
- Used to perform various traffic usage/characterization analysis/intrusion detection

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BcN 품질 측정도구

- 응용 서비스별 품질 측정 지원
- 다양한 **granularity**별 품질 측정 지원
- **BcN** 환경하에서 다양한 사용자 요구에 따른 측정 지원 **(customized scripts)**
- 통합망 환경 지원 (유무선, 방송망 연동, 통합망 지원)
- 측정데이터의 저장 **(SLA**에 따른 분쟁 조정 지원**)**
- **RDBMS**를 사용한 다양한 측정데이터의 검색 지원
- 각기 다른 측정 도구들 사이의 상호운용 지원
- **QoE, QoS, NP** 지표간 연계 방안 수립
- 도메인간 표준화된 측정 정보 전달 체계
- 표준화된 품질지표 측정 결과 제공
- 측정된 품질 지표의 열화 요인 분석 지원

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Concluding Remarks

- **BcN = IP-based unified core network + heterogeneous access networks**

→ **requires robust, acute intra- and inter-domain TE**

- **For resource optimization**
  - QoS-based routing
  - State dependent load balancing
- **For E2E QoS support**
  - Static and dynamic QoS apportionment
  - QoS-guaranteeing buffer management, scheduling, CAC, policing, marking
  - QoS class, parameter mapping
  - QoS measurement
  - QoS fantasy is a zero sum game
    - → Must consider a fairness problem
- **For high reliability and availability**
  - Sub-path protection
  - Fast restoration

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