

(Quality of Service: QoS)

ATM Overlay, IP over SONET/SDH, IP over WDM 가 MPLS
QoS, VoIP, 가

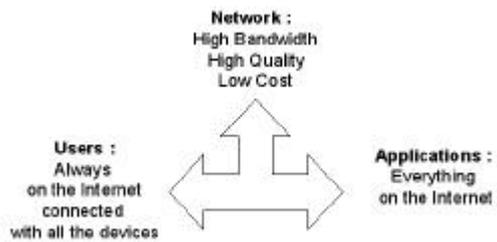
I.

2000

IP/ATM/SONET/WDM ATM 가
가, ATM
IP/SONET/WDM, IP/WDM, IP/10GbE

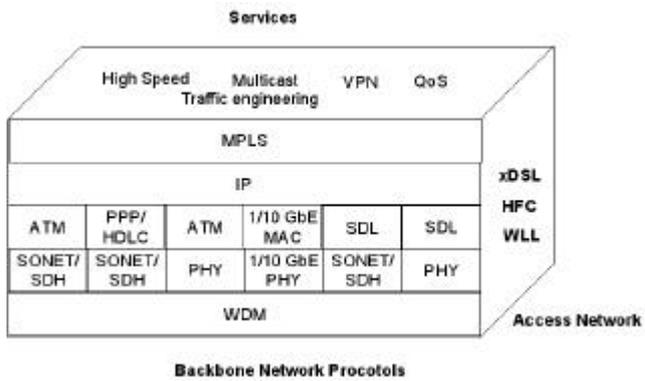
(Quality of Service: QoS),

가 MPLS
가 ~



1.

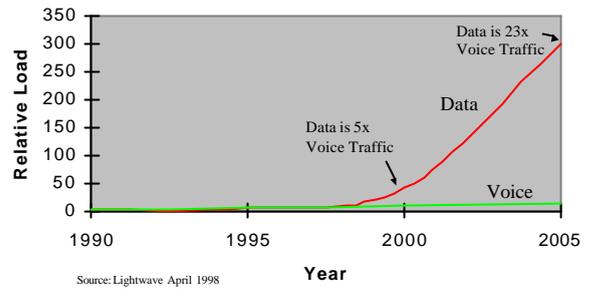
가
가
MMDS/LMDS, WLL xDSL, Cable Modem,
/ QoS
(2).



2.

가 6 (4). 가 2 가 2001 - 2002 35 Tbps (aggregated)

[4].



II.

가

4.

가 [5]

1.

가

가

가

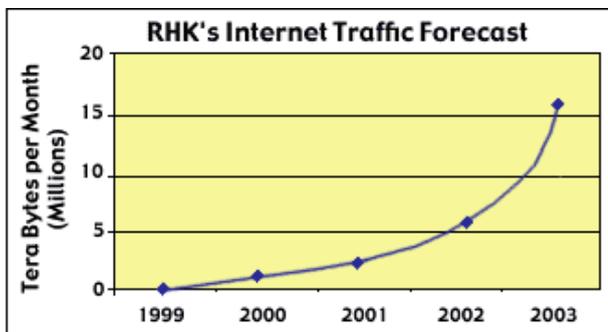
가 [2] 1999 2 7 6 , 2000 3 7 5 , 2005 10 [3].

가

가

2000

4



3.

[1]

2.

[1] , 350,000 TB , 3 2000

similarity),

[5].

(burst)

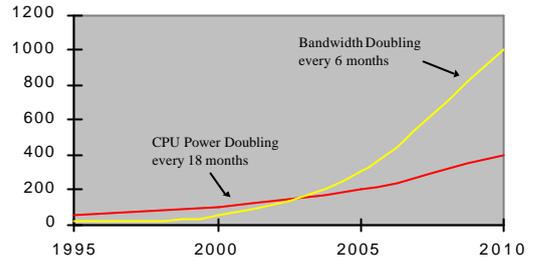
가

10 %

(Self-

ISP(Internet Service Provider) OC-48(2.4Gbps) ATM, SONET/SDH

ADSL 가 가



5. CPU 가 [5]

(Congestion)
(Smoothing) 가

, VoIP,

III.

(Server

farm)

1. IP

IP

IP over ATM, MPLS, IP over WDM

(IP address lookup)

(IP) 가
ATM 2

3

[6].

(flow

control) 가

DNS, CPU

가 가 IP

, I/O

가 가

가

CPU

IP
(Longest Prefix Matching:LPM)
가

5 CPU

2 QoS

2

QoS 가 가

IP QoS 가 가 QoS

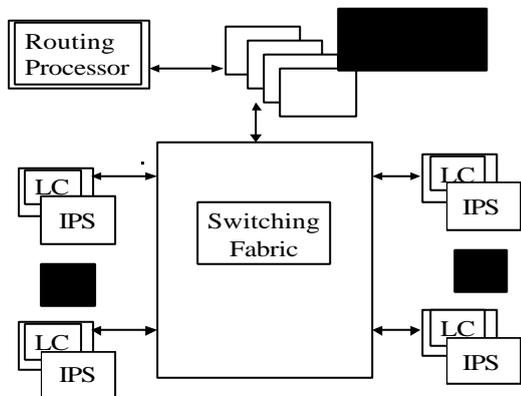
7.

IP
IP 가
(Connection),
(Flow)
WFQ(Weighted Fair Queueing)
QoS
가
가
(Switching Fabric)
가

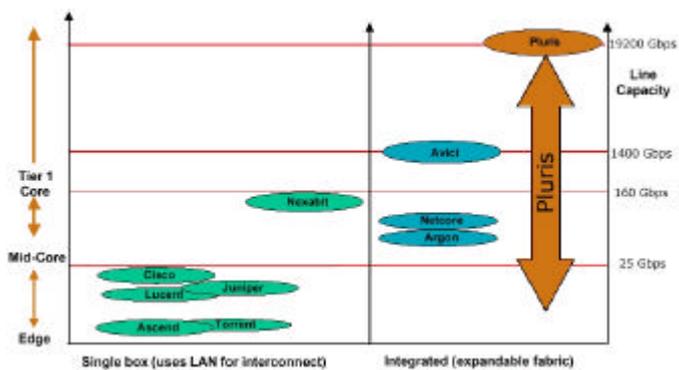
IP 가 가
Patricia trie
32
1-4
()
Multibit
trie, Index
가 가
1
[32][33][34].

ATM IP 가 가
가 (8).

(6, 7).



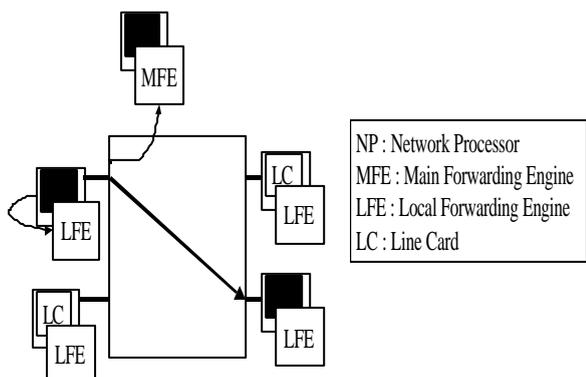
6.



8.

[35]

IP QoS
(Integrated Service: IntServ)
(Differentiated Service: DiffServ)가
가



2.

ATM
ATM
IP/ATM
가
IP over SONET/SDH
ATM
IP over WDM
가

MPLS(Multi-Protocol Label Switching)

10 가
가

- IP over ATM

ATM,
SONET/SDH TDM,
DI

ATM

가

ATM

, IP
VC/VP

가

IP

IP

IP over ATM

ATM

10 %

“cell tax”

SAR(Segmentation and Reassembly)

가

40 Gbps(OC-768)

가

ATM

SVC

, SVC

IP over ATM

ATM

가

Internet2

MCI
Services)

vBNS(very-high Bandwidth Network
IP over ATM

9

vBNS POP(Point of Presence)

, ATM

POP

UBR PVP

PVC

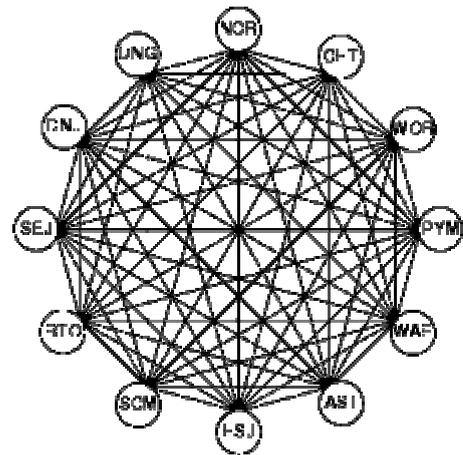
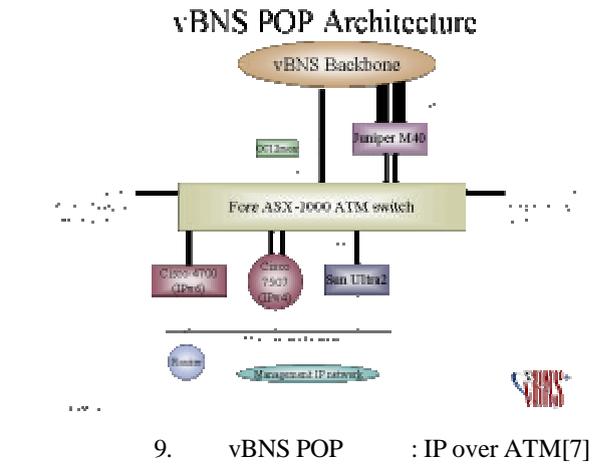
IP

vBNS

SONET

IP over ATM

10



- IP over SONET/SDH

SONET SDH(Synchronous Digital Hierarchy)
가 (American National Standards
Institute: ANSI) 51 Mbps(OC-1) 9.8
Gbps(OC-192)

SONET
(OAM: Operations and Maintenance)

IP
over SONET IP over ATM “cell tax”
2 % , IP
ATM 1(
, SONET

¹ IP IP over SONET

2 %

ATM SAR(Segmentation and Reassembly) 가 가 . , 가 가 .

IP over SONET 가 100 가 DWDM(Dense WDM) .

IP over SONET, IP/PPP/HDLC over SONET Internet Engineering Task Force(IETF) Request for Comments(RFC) 1619[9] SONET/SDH ATM WDM , SONET/SDH IP 가 .

SONET/SDH OC-x WDM SONET TDM , WDM .

3 SONET/SDH 가 TDM 가 . , TDM .

SONET/SDH / 50 ms , IP , SONET/SDH , WDM () .

SONET/SDH , 40 Gbps TDM , WDM Gbps . WDM FDM .

GPS(Global Positioning System) IP , SONET IP over WDM 가 .

IP over SONET HDLC (delineation) , ADM(Add-Drop Multiplexer), OXC/WRS(Optical Cross-Connect/Wavelength Routing Switch) 16 , 32, 96 .

(destuffing) (stuffing) STS-48c Lucent 200, 1000 .

2.5 Gbps (OC-48) 가 WDM .

SDL(Simplified Data Link) IP ATM (Opto-Electronic-Opto: OEO) , WDM .

- **IP over WDM[11][12]** (lightpath) (channel) WDM(Wavelength Division Multiplexing) .

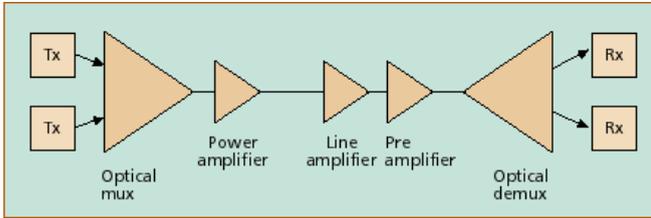
FDW(Frequency Division Multiplexing) 가 WDM 11 DFB , .

1300 1500 nm 가 . , .

가 OADM(Optical ADM) 가 . WDM .

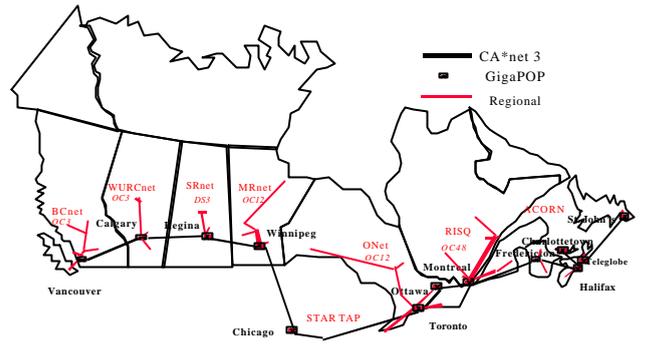
DFB(Distributed Feedback doped Fiber Amplifier), (Photodetector) EDFA(Erbium- 가 .

WDM

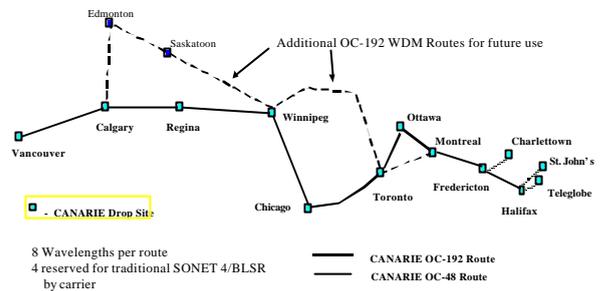


11. WDM [11]

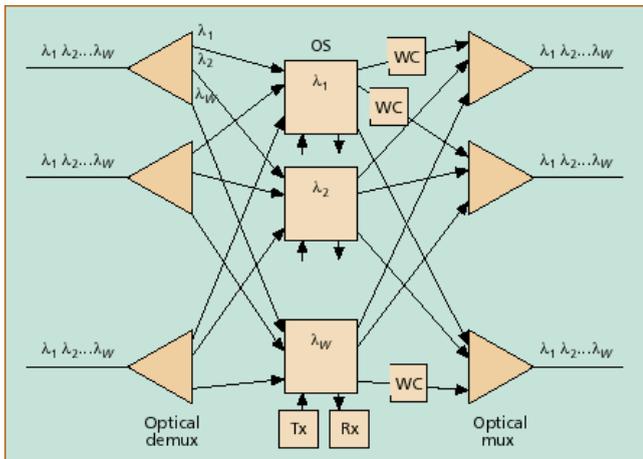
WDM (Wavelength Crossconnect: WXC) / (Optical Transport Network: OTN) lightpath 가 가 (Gbps), OC-192(10 Gbps)



13. CA*net3 [13]



14. Ca*net3 [13]



12. Wavelength Cross-Connect [11]

WDM MONET ACTS(Advanced Communications Technologies and Services) pan-European optical network 가 CANARIE CA*net3[13] 8 가 OC-192 13 GigaPOP (13,

10 Gigabit Ethernet 가

1 가 1.25 Gbps Tx/Rx 2.5 Gbps 1 가 8 data bits 10 bit

SONET 25 % WDM 10 10 가 IEEE 10

가 1999 3 MAS(Multilevel Analog Signaling), NRG, MB810[10] 1.25 Gbps OC-48 WDM 10 가 OC-192 WDM 10 가 10 Gbps 가 SONET 1/10 가

가 , QoS

, 802.1Q/p , RSVP

ATM , VC/VP (Merging)

- **Multi-Protocol Label Switching(MPLS)**

MPLS (label) ATM 가 가

가 , MPLS

IP , ARIS IETF

MPLS(Multi-Protocol Label Switching) WG [14][15]

MPLS QoS(Quality of Service) VPN(Virtual Private Network) 가 ATM VC/VP IGP , IP

가 CR-LDP[16]

MPLS LER(Label Edge Router) (Label) , MPLS

MPLS LSR(Label Switched Router) IP (Longest Prefix Matching) 가 (Virtual Private Network) MPLS LSP

MPLS SONET

MPLS LDP(Label Distribution Protocol) LER(Label Edge Router) FEC(Forwarding Equivalent Class) MPLS MPLS

prefix (Granularity) PQ(Port Quadruple), PQT(Port Quadruple with TOS), HP(Host Pairs), NP(Network Pairs), DN(Destination Network), ER(Egress Router), NAS(Next-hop AS), DAS(Destination AS) SST(Source Specific Tree), SMT(Shared Multicast Tree) MPLS 1) , 2) (Route pinning), 3) 가 (가), 4) (fast rerouting)

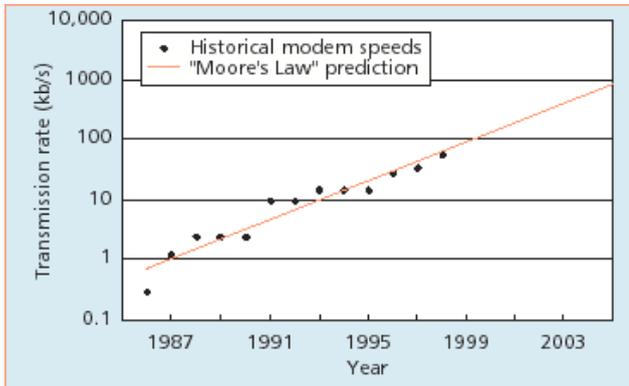
(Label Assignment) WDM [18]가 MPLS 가

(Label Allocation) (Binding) , QoS , EXP

3.

가 [19]

가
(15).



15. 가 [19]

가
4 가

(copper wire) xDSL (x
Digital Subscriber Line), CATV
HFC (Hybrid Fiber Coaxial), (wireless in the
loop), (fiber in the loop) 4 가

3.1 xDSL[36]

- (leased lines):
1 – 2 Mbps
frame relay
512 Kbps 2 Mbps
가
(central office)
T1 (1.544 Mbps) E1 (2.048
Mbps) 1.5
MHz

가

- **HDSL(High bit rate DSL):** HDSL ISDN DSL
T1 E1
copper wire
(modulation)
T1 80 – 240
KHz
3.6 Km

- **ADSL (Asymmetric DSL):** ADSL HDSL
HDSL ADSL
(VoD: Video On Demand)
(downstream)
가
0 – 4 KHz POTS (Plain Old Telephony
Service) , 4 – 100 KHz
640 Kbps
100 KHz – 1 MHz
8 Mbps

- **VDSL (Very high speed DSL):** VDSL ADSL
가 가
51.84 Mbps 가 가
1.62 Mbps
19.2 Mbps
300 m 1500 m 가 VDSL
FTTC (fiber to the curb)
/ POTS ISDN access 0 – 80 KHz
300 – 700 KHz
1 MHz

3.2 HFC (Hybrid Fiber Coaxial)

HFC CATV
CATV
, HFC ATM
(point-to-
point) 가 (central office)

OLT (optical line termination),
 ONU (optical network unit)
 ONU (optical signal)가
 passive coaxial tree
 x-DSL
 HFC (point-to-multipoint)
 가
 (CPE: customer premises equipment)
 coaxial cable
 (MAC: media access
 control) . ATM
 1200
 (TDM:
 time division multiplexing) (FDM:
 frequency division multiplexing)
 , timing,
 , 가
 ,
 5 – 50 MHz 1 – 10
 Mbps . 50 – 450 MHz
 ,
 400 MHz 50 CATV
 . 450 – 750 MHz
 40 Mbps

3.3 Fiber in the loop (FITL)

(optical fiber)
 가 20
 carrier ()
 가
 local loop
 OLT ONU
 (fiber distribution network) 가
 OLT (CO) , ONU curb ()
 (FTTC: fiber to the curb).
 (FTTB: Fiber To The Building) (FTTH:
 Fiber To The Home)
 passive optical tree
 , CO 가 broadcast
 Passive Optical Network (PON)
 64 ONU 가 OLT
 CPE
 laser diode
 (MAC)

SDH self-healing loop for the feeder network:

SDH
 (synchronous digital hierarchy)
 Plesiochronous Digital Hierarchy (PDH) SDH
 가 , PDH overhead
 (regenerator section)
 SDH regenerator section
 2
 multiplexer section optical path
 SDH
 telecommunication Management Network (TMN)
 . TMN 3가
 가 carrier
 (public switched network)
 feeder network SDH
 . SDH self-healing loop
 가 SDH self-
 healing loop
 add-drop multiplexer
 (ADM) 가 SDH ADM
 가/

APON (ATM over passive optical network):

passive optical network (PON)
 (MAC) 1990
 ATM
 MAC
 APON
 APON 622
 Mbps,
 155 Mbps
 (full-duplex)
 1.5 ? 1.3 ?
 . 16 64
 ONU 가 PON 가 PON
 10 Km , ONU
 CPE , ATM
 , APON
 encapsulation ONU
 (PLOAM: Physical Layer Operation
 And Management) ATM
 가 APON
 ATM 1 octet overhead 가
 overhead
 (ONU)

Fiber in the loop : feeder network SDH
 self-healing ring 가
 (Distribution Network) PON

carrier

10 ms , 12

. TDD

PON

. DECT

. APON PON

ATM . PON

가

SuperPON . SuperPON

passive filter optical amplifier

100 Km 2048 ONU

2.4 Gbps

311 Mbps 가

(WDM: wavelength division multiplexing)

PON 가

3.4 Wireless in the loop (WITL)

WITL Radio In The Loop (RITL)

. WITL

carrier

WITL carrier 가

. WITL

가

GSM, IS-95

DECT, personal handy phone system,

PACS cordless . cordless

WITL

local loop 가

(fading, interference)

cordless

. cordless (CO)

(BS: base station) passive coaxial tree

passive optical tree 가

- **DECT** : DECT

MAC

omnidirectional 100m,

directional 4Km

DECT cordless

directive

. 1880 – 1900 MHz 1.7 MHz

(multiple access) TDMA Time

Division Duplex (TDD) . TDMA

32 Kbps ADPCM

. 1997 DECT 480 Kbps

full duplex ISDN

. DECT ISDN GSM

- **LMDS/MMDS: MMDS** 가

. Microwave Multi-point

Distribution Service Multipoint Multi-channel

Distribution Service . DECT

MMDS

. MMDS 1960

MMDS

. MMDS

가/

2.5 – 2.7 GHz 27.5 – 28.35 GHz

가 40.5 –

42.5 GHz . DECT

MMDS 2GHz

가

MMDS

shadowing 4 – 50 Km

가 . LMDS (Local Multipoint Distribution

Service) digital MMDS

local loop

CDMA

waveform (pseudo-random

pattern) . pattern

- **Wireless ATM:** wireless LAN

HIPERLAN IEEE 802.11 wireless MAC

ATM

ATM

local loop

wireless ATM (WATM) . WATM

picocell 100 – 500 m TDD

ATM

. ATM

- **Satellite access:**

. VSAT (Very Small Aperture Terminal)

. Iridium, Globalstar, Teledesic

LEO (low-earth orbit)

가 ,
Mbps

initial frame space
hidden terminal
request-to-send (RTS), clear-to-send (CTS)

point coordination function (PCF)

4. [37]
WITL(Wireless In The Loop)
WLL(Wireless Local Loop)
(Central Office: CO)
(Customer Premises Equipment: CPE)
()
LAN GPRS

- **HIPERLAN**: ETSI Ethernet
high performance LAN
(HIPERLAN)
multi-hop routing,
23.529 Mbps
LAN 5.15 – 5.30
GHz, 17.1 GHz – 17.2 GHz
5 GHz

- **GPRS (General Packet Radio Service)**: GPRS
GSM

IV.

, GSM 3 가
()
(mobile station)
bursty
115 Kbps
GPRS
(TCP/IP, X.25)

QoS

CDPD
infrastructure
가 , GPRS GSM 가

1.

LAN
WaveLAN direct sequence frequency
hopping 2 Mbps
LAN
IEEE 802.11 HIPERLAN

RSVP(Resource ReSerVation Protocol)
(Integrated Services)[20]
(Differentiated Services)[21]

RSVP IP

- **IEEE 802.11**: 3 가 가
: 2.4 GHz ISM band frequency
hopping (FH), 2.4 GHz ISM band direct sequence (DS),
infrared (IR). FH DS
FH
DS
CSMA/CD(carrier sense multiple
access/collision avoidance) distributed
coordination function (DCF)
exponential backoff

DSCP(Differentiated Service Code
Point)[22]

EF(Expedited
Forwarding), AF(Assured Forwarding), BE(Best-effort)
PHB(Per-Hop Behavior)

PHB
(classify, mark, shape, drop)

(SLA: Service Level Agreement)

QoS

BB(Bandwidth Broker)

가

[28].

QoS

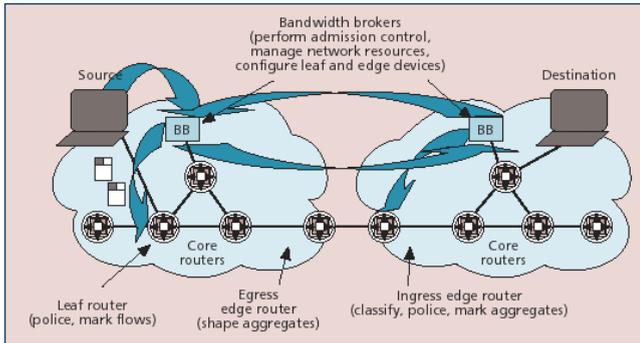
Internet2

3.

Qbone

[23]

가



16.

[23]

가

IGP

overlay

ATM

PVC

MPLS

[17].

2.

[24]

MPLS

가

QoS

, LSP

, LSP

LSP

RSVP

CR-LDP

가

LSP

IGP

LSP

LSP 가

LSP

1989 Mbone(Multicast Backbone)

가

Distance Vector Multicast Routing Protocol (DVMRP), Protocol Independent Multicast Dense Mode(PIM-DM)

PIM-SM BGP RP

MBGP

가

Multicast Source Discovery

Protocol (MSDP)[24]

가

Mbone

가

: MPLS IGP

Border Gateway Multicast Protocol(BGMP) [26], Multicast Address Set Claim(MASC)[27]

가

LSP

LSP

QoS

QoS

, MPLS

17).

SIP

가

SIP

V.

가

(QoS)
(Best Effort Service)

VoIP

가

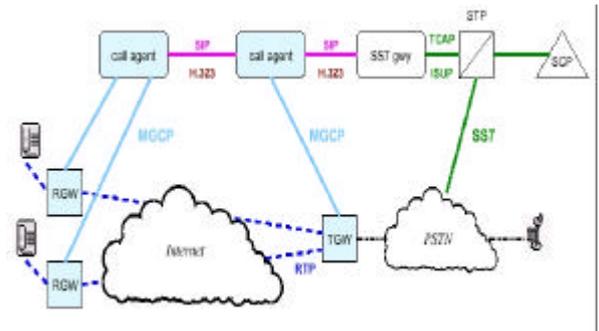
가

VoIP,
가

1. VoIP(Voice over IP)

(Internet Telephony)

VoIP



H.323 IETF

ITU-T
SIP, MGCP

VoIP

SS7

LAN

17. VoIP

H.323

H.323

ATM

MPLS

H.323

VoIP

IntServ

DiffServ

가

가

IP

VoIP

IETF(Internet Engineering Task Force)
SIP(Session Initiation Protocol) H.323

All IP

가

가

2.

(Digital Video)

VoD

H.323
SIP

(Signaling)

Gatekeeper
Call Agent 가
Media

Gateway 가
Gateway

Call Agent 가 Media
MGCP(Media Gateway Control Protocol)

200 ms
VoD

2

.(

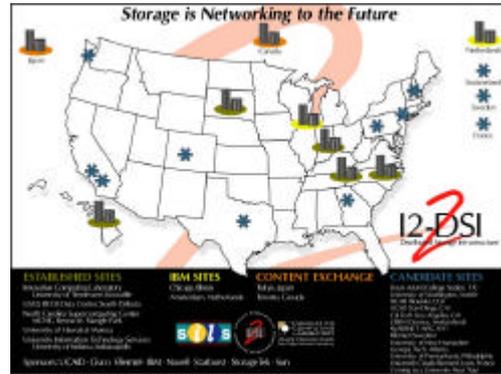
가 가

MPEG1/2

가

Internet2

HDTV IEEE 1394



[29].

18. Internet2 DSI [30]

MPEG4

300 Kbps

가

4. 가 (Internet Appliance)

가

. WAP(Wireless Application Protocol), IMT-2000

가 . 1 2005
70 % PC

3. (Network Storage System)

가
가

1. [2](:)

	2000	2002	2005
Web/Internet Appliances-in-use	21.5	139.8	596
Web Appliance share of Internet Users	5.7%	25.7%	71.0%
PCs-in-use	521	695	1,008
Internet Users	375	544	840

POP

가

, 가

가
TV

TV

가

Internet2

TV

가

DSI(Distributed Storage Infrastructure) [30]
가 18 DSI 가

, 가
가

가

VI.

VoIP, QoS, ATM, POS, ATM vision, GbE vision, Robust packet over SONET, Robust packet over fiber

QoS, IP over WDM/GbE

MPLS, IP, QoS 가, HFC, xDSL 가

- [1] RHK, <http://www.rhk.com>
- [2] eTForecasts, <http://www.etforecasts.com>
- [3] ARG, <http://www.angusreid.com>
- [4] A. Oldyzko, "Data Networks Are Lightly Utilized, and Will Stay That Way," IT Professional vol. 1, no. 2, pp. 67-69, March/April 1999
- [5] T.W. Chung, J. Coulter, J. Fitchett, S. Mokbel, B. S. Arnaud, "Architectural and Engineering Issues for Building an Optical Internet," Ca*net2 Draft, 1998
- [6] C. Huitema, "Required Steps Towards High Quality Internet Services," Re-engineering the Internet, 1998
- [7] <http://www.vbns.net>
- [8] J. Manchester, J. Anderson, B. Doshi, and S. Dravida, "IP over SONET," IEEE Communications Mag. May 1998
- [9] W. Simpson, "PPP over SONET/SDH," RFC1619, May 1994
- [10] <http://ccl.cnu.ac.kr/LineCoding>
- [11] D. Cavendish, "Evolution of Optical Transport Technologies: From SONET/SDH to WDM," IEEE Communications, June 2000
- [12] P. Bonenfant and A. Rodriguez-Moral, "Optical Data Networking," IEEE Communications, March 2000
- [13] <http://www.canet3.net>
- [14] R. Callon et al., "A Framework for Multiprotocol Label Switching," IETF Internet draft, work in progress, Sep. 1999
- [15] E. Rosen, A. Viswanathan, and R. Callon,

- "Multiprotocol Label Switching Architecture," IETF Internet draft, work in progress, Aug. 1999.
- [16] B. Jamoussi et al., "Constraint-Based LSP Setup Using LDP," IETF Internet draft, work in progress, Sept. 1999.
- [17] D. Awduche et al., "Requirements for Traffic Engineering Over MPLS," RFC 2702, Sept. 1999
- [18] D. Awduche et al., "Multi-Protocol Lambda Switching: Combining MPLS Traffic Engineering Control with Optical Crossconnects," Internet draft, Nov. 1999.
- [19] C. A. Eldering, M. L. Sylla, and J. A. Eisenach, "Is There a Moore's Law for Bandwidth?," IEEE Communications, Oct. 1999
- [20] R. Braden, D. Clark, and S. Shenker, "Integrated Services in the Internet Architecture: An Overview," IETF RFC 1633, June 1994
- [21] D. Black et al., "An Architecture for Differentiated Services," IETF RFC 2475, Dec. 1998.
- [22] K. Nichols et al., "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers," IETF RFC 2474, Dec. 1998.
- [23] <http://www.internet2.edu/qbone>
- [24] K. C. Almeroth, "The Evolution of Multicast: From the Mbone to Interdomain Multicast to Internet2 Deployment," IEEE Network, Jan. 2000
- [25] D. Farinacci et al., "Multicast Source Discovery Protocol (MSDP)," Internet draft, Feb. 2000.
- [26] D. Thaler, D. Estrin, D. Meyer, Border Gateway Multicast Protocol (BGMP): Protocol Specification, Internet draft, March 2000
- [27] D. Estrin, R. Govindan, M. Handley, S. Kumar, P. Radoslavov, and D. Thaler, "The Multicast Address-Set Claim (MASC) Protocol," Internet draft, Jan. 2000
- [28] B. Whetten, L. Vicisano, R. Kermode, M. Handley, S. Floyd, M. Luby, "Reliable Multicast Transport Building Blocks for One-to-Many Bulk-Data Transfer," March 2000
- [29] <http://www.researchchannel.com/hdtv/>
- [30] <http://dsi.internet2.edu>
- [31] Henry C.B.Chan, Hussein M.Alnuweiri and Victor C.M Leung, "A Framework for Optimizing the Cost and Performance of Next-Generation IP Routers", IEEE Journal of Selected Areas in Communications, Vol. 17 No.6, pp.1013-1029, June 1999
- [32] Nen-Fu Huang and Shi-ming Zhao, "A Novel IP-Routing Looking Scheme and Hardware Architecture for Multigigabit Switching Routers", IEEE Journal of Selected Areas in Communications, Vol. 17 No.6, pp.1093-1104, June 1999
- [33] Mikael Degermark, et al., "Small Forwarding Tables for Fast Routing Lookups", ACM SIGCOMM, Sep. 1997
- [34] Pankaj Gupta, Steven Lin, and Nick McKeown, "Routing Lookups in Hardware at Memory Speeds." IEEE Infocom, April 1998.
- [35] " ", HSN 2000, pp. 357-370, Feb 2000
- [36] M. Gagnarie, "An Overview of Broad-Band Access Technologies," Proceedings of THE IEEE, vol. 85, no. 12, Dec. 1997
- [37] A. K. Salkintzis, "A Survey of Mobile Data Networks," IEEE Communications Surveys, vol. 2 no. 3, third quarter 1999



1995. 2: ()
 1997. 2: ()
 1997.3 ~ : ()
 : , MPLS,
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