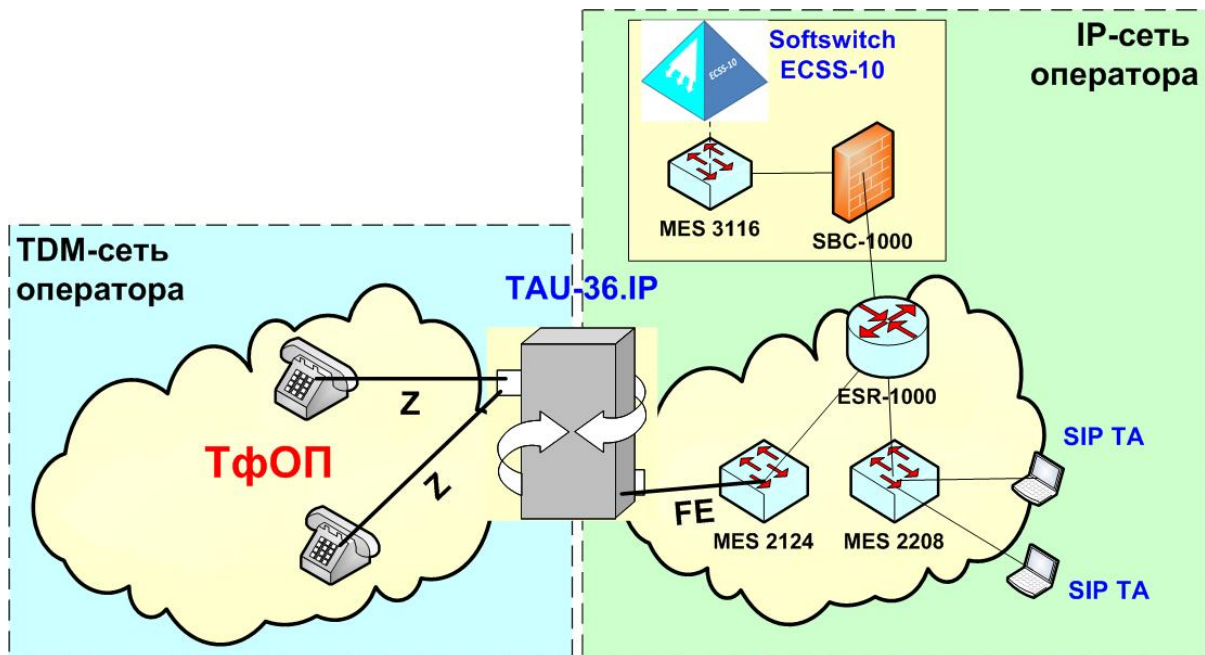


1. , IP, NGN

TAU, , :

- 0, ;
- , (, IP-).

TAU /N-ISDN (Z-, BRI), IP- (1.1):



1.1 – TAU

, IP-, (NGN).

– (PSTN – Public Switched Telephone Network) – , .

20-, , – 80- 20-. () 0).

:

- 0;
- 0, ;
- 0 0, (TDM);
- («»);
- , ITU-T E.164 (15 , 1 3 ITU-T, 12).

:

- ;
- 0 ;
- (.2 3);
- (dial-up).

, , :

- (,) ;
- ;
- 0 .

:

1. :

- « »;
- ;
- , « »;
- .

2. :

- ;
- .

1 TDM

, – .

(, / (TDM), , .) :

- (150);
- (0,3...3,4, 40);
- .

, :

- ITU-T Q.xxx – ;
- ITU-T G.xxx – ;
- ITU-T E.xxx – , , , ;
- 45.196 – ;
- 45.120 – ;
- 45.68-96 – () ;
- 45.54-95 – . . .

1.1

, ():

- (/ ,);
- , :
- 0, , ;
- , ;
- (,).

, : «-», – 20 . – , « »- , . , 100 000, , :

- – $I(I)$;
- , – (), . () ();
- – , , 0 () 0. 2005, , – Softswitch, .

, , , SDH/WDM.

SDH/WDM, (PDH) 1 2, , , TDM- , , – .

:

- , (, .);
- ;
- .

, , , .

, :

- . 28 2005 . N 161
- , . 28 1995 .
- 45.09-2001.

1.1.1 OSI

OSI (, ,) .

() (– ISDN) , , , 4- .

(DSS1), 7 (-7/ISUP), .

, /ISDN .

- :

- **U (User)**, 0 (,);
- **C (Control)**, , , ;
- **(Management)**, , (– O&M).

() /ISDN :

(Z- 1–2).

Z- :

1. 0 .
2. 0 -240 TAU-36/72.IP .
3. 2- .

, , Z- , 0 0:

	1 0 (-, , , ,) 		2 0 (-, , , ,)	
L1 . (OSI)			L1 . (OSI)	
L1 (-, -)	Z-if		Z-if	L1 – BORSCHT (60, , 25, 110, ,)

1.2 – Z-

(Z-), **U**() :

	1 (-/ ,) 		2 (-, , , ,) (, /)	
L1 (-/ ,)	Z-if		Z-if	L1 – BORSCHT (-/ - ,)

1.3 – Z- U

0 0 0.

– BORSCHT.

B (battery feed) – – (35) . – 48 – 60.

O (over voltage) – – , (,), .

R (ringing) – – 90...110, 25. , – .

S (supervision, signaling) – – , , , .

C (coding) – – (/). - .

H (hybrid) – – .

T (testing) – – . - 0, , , , .

:

- ;
- b b;
- b;
- b;
- .

BORSCHT, , «». , 45.54-95 [8], , , , 60 +20% / -10%, 25 – 90 110 ..

1.1.2 (, PBX)

, , , 0), (), , , .

(– PBX – *Private Branch eXchange*) , .

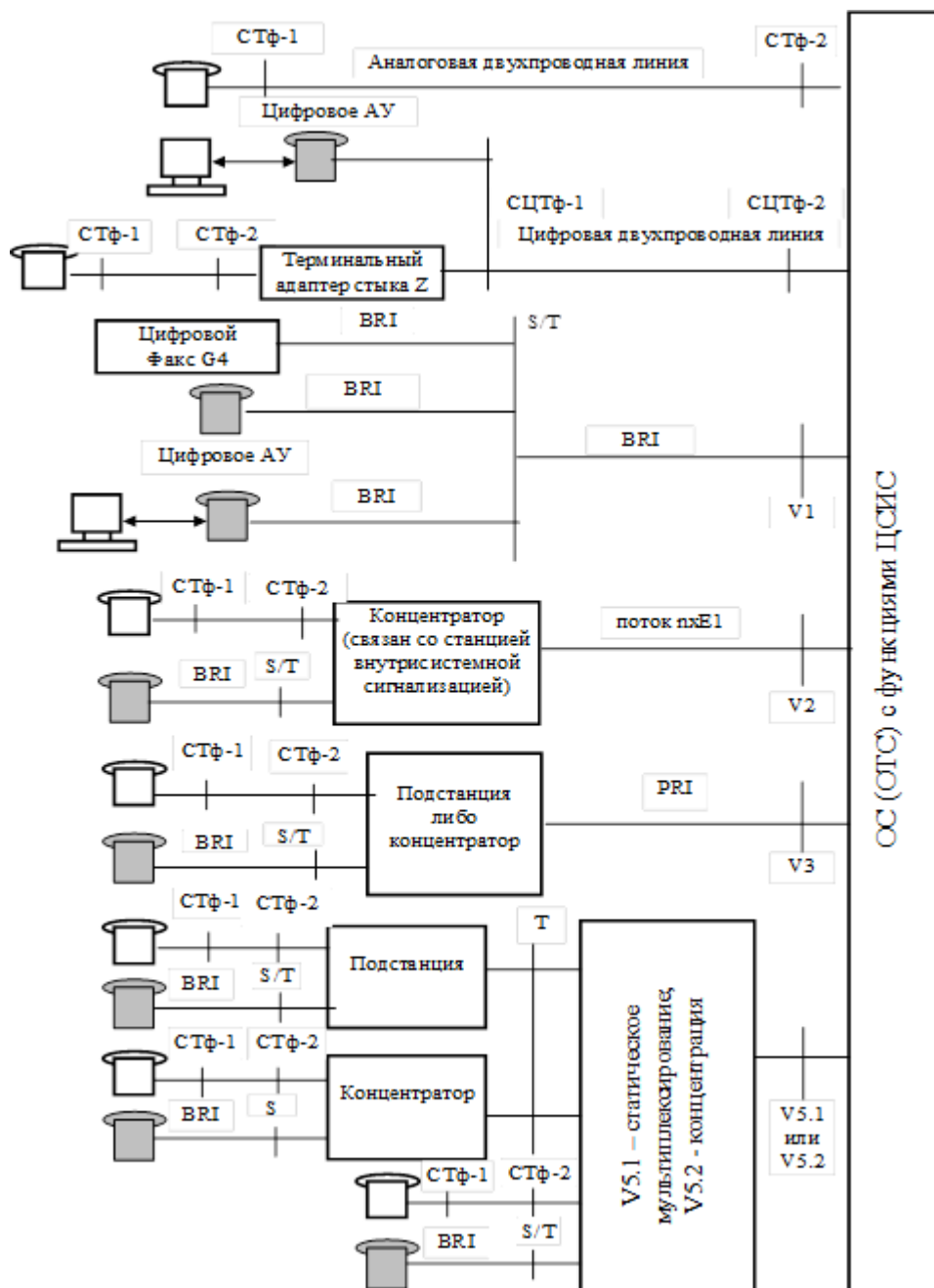
1.1.3

/ (,,) , .

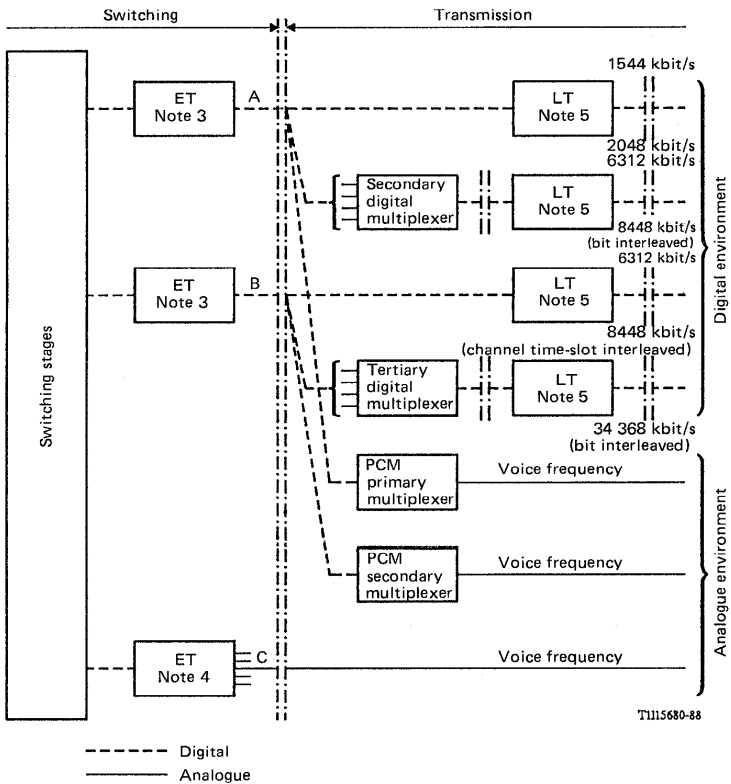
OSI, , L1 , , , ..

() ITU-T Q.511 Q.551 [10, 11], , () 45.196-2001 [5].

() (TDM) .45-196 1.4:

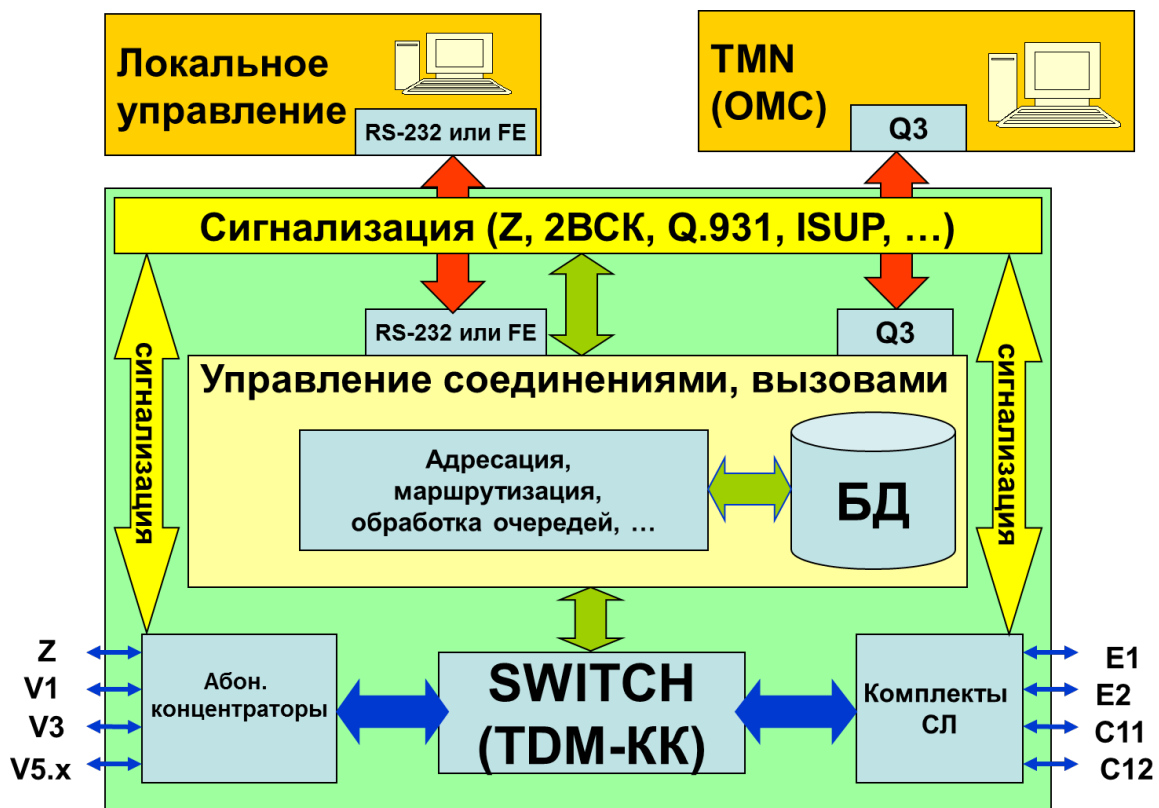


() (Interfaces towards other exchanges) () (TDM) ITU-T Q.511 1.5:



1.5 – ()

1 . , (-) .
 , , . 0, - , , ISDN (4-).
 4- (ISDN) 1.6:



1.6 – 4-

« » - Softswitch (5-).

1.1.4

(DSS1, -7) () . 0, :

- ;
- ;
- () ;
- ;
- ;
- ;
- () .

N-ISDN :

- ISDN – DSS1 (Q.931/Q.921 D-);
- – -7 (ISUP/MTP -).

« », ISUP – ISUP-R-2000 [12].

ISDN/PLMN (1.1):

1.1 – ISDN/PLMN

	PSTN / ISDN	PLMN
	CIC	FDMA/TDMA
		CIC

()		(CdPN) (CgPN) , D, E, ...()	(CdPN) (CgPN) , D, E, ...
0	(NCI, TMR, BC)	(, – G.711, V.110,...)	(, – G.711, V.110,...)
		, ...	, ...
		~, ...	~, ...
(roaming,)		/ (ISDN -)	/

/ISDN, , , [13].

1.1.4.1

(Z-) , Z- ., Z , , Z- . 45.54-95 [8] , , Z- .
– DSS1 (Q.931/Q.921 D-), BRI (V1) PRI (V3).

1.1.4.2

, , , , (), .
, , [13], , ():
1.2 –

1.			
2. 2	7.18; 7.19 [13]		
3. 2		7.20 [13]	
4. ()		7.20 [13]	
5. (2600)	7.10; 7.22 [13]		
6. 1 ()		7.11; 7.12 [13]	
7. 1 («»)		*	
8. V 5.1			
9. V 5.2			
10.	. 7.2.4.2.4 [13]		
11. EDSS1	ISDN		
12.			X ITU-T
(,)			
13.	. 7.4 [13]		
	. 7.28; 7.34 [13]		
14.	. 7.4 [13]		
	. 7.27-7.28; 7.34 [13]		
15.	. 7.4 [13]		
	. 7.27-7.28; 7.34 [13]		
: * – , : .			

1.1.5

. .

/N-ISDN/PLMN, (TDM-), (10^{-5} , +/- 10), . PDH (E1), SDH (STM-1). , ().
VoIP ., 100 400, IP- (– IPDV) 10 30 ., VoIP () , TDM-. Ethernet-, TDM-.
IP-Ethernet-, , , 10...30. IP-Ethernet- VoIP.
VoIP, NTP (), .

NTP – , , , NTP-. RTP/RTCP « IP- – IPTD » « – IPDV ».

NTP « /» (stratum). 1 , GPS, . 2 1 .

NTP 64- (8), 32- 32- , 2^{32} 2^{32} .

<http://support.ntp.org/bin/view/Servers/StratumOneTimeServers> .

20 NTP- 1.

NTP-, :

1.3 – NTP-

ServerForm	ntp.deman.ru	ntp.ix.ru
ServerStratum	StratumOne	StratumOne
CountryCode	RU	RU
Hostname	ntp.deman.ru	ntp.ix.ru
IP Address	212.20.50.208	194.190.168.1
IPv6 Address		2001:6d0:ffd4::1
UseDNS	Yes	Yes
PoolMember	Yes	Yes
ServerLocation	Novosibirsk, Russia	Novosibirsk
GeographicCoordinates		55°1N 82°55E
ServerSynchronization	NTP V4 primary (stratum 1), GPS (PPS), PC/FreeBSD	GLONASS / GPS
ServiceArea	Russia	Any, anycast cluster used
AccessPolicy	OpenAccess	OpenAccess
AccessDetails		http://www.nsk-ix.ru/network/ntp.html
ServerContact	Michael Demidoff hostmaster@deman.ru	MSK-IX http://www.nsk-ix.ru/ (noc@ix.ru)

1.1.6

. 1.7, , [4].



- : /
- :
- ,
- .
- ,
- , //
- (PNP): , / E.164 , ()
- E.164: , , , , , E.164 , , E.164 ()
- [ITU-T E.164]: , , , , ,
- : , (SN))
- : , () [N(S)N]

— , , •

$$, \quad (, \quad), \quad , \quad .$$

1. E.164

- , , 3 , , 1 ;
- , , 2 5 , 1 3 , 1 2 ;
- , , , - «» . (0): , , .

* * * , * : () , , () .

— , ,

3 3 3 3 *

* , * , *

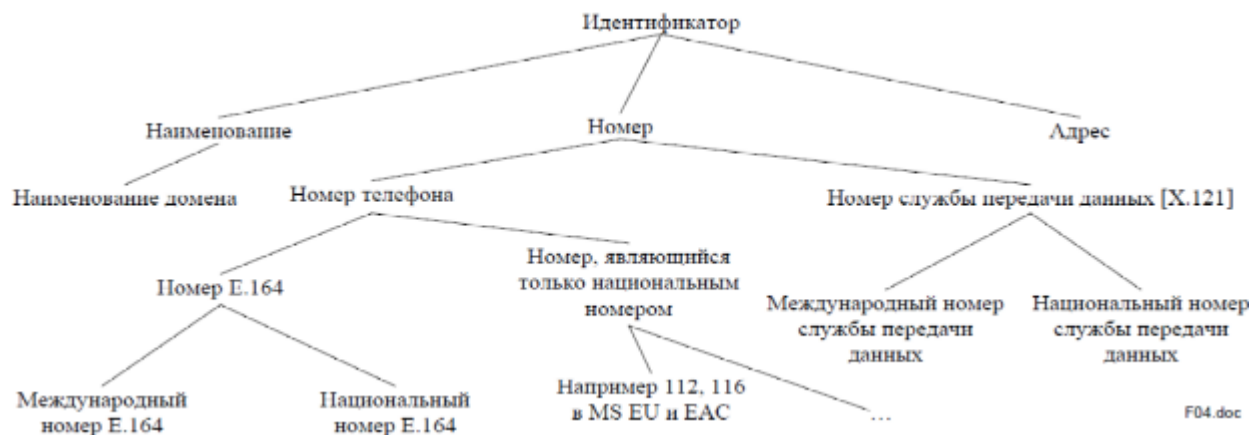
•

и, следовательно, «0», «8» и «8».

• • • •

• • • •

, . 1.8, , E.164.



F04.doc

1.8 – .164

: .

: , , .

[ITU-T E.910]: -, (TLD) , , .

E.164: , , , [ITU-T E.164]. , .

: , . – . , .

() [b-ITU-T E.164-Sup.2]: E.164, .

∴ « E.164».

(ID): , , , , . ().

E.164; ; ; , . .164 «» . , , , (,). ". [b-IETF RFC 3966], URI tel , E.164 .

[ITU-T E.190]: , -T, [ITU-T E.164] [ITU-T E.212].

∴ « E.164» « ».

MSISDN (); : E.164 , .

: , (,). , .

E.164: (NNP) . [ITU-T E.164] , , , () E.164 . E.164 () [N(S)N], (NDC) (SN), , , (). NDC N(S)N, N(S)N SN . [b-IETF RFC 3966], URI tel , E.164 .

: , (NNP), - . E.164 E.164, [ITU-T E.164]. . [b-IETF RFC 3966], URI tel , E.164 .

[b-ITU-T E.164-Sup.2]: E.164, .

[ITU-T E.191]: – .

; ; / , , / . / .

[b-ITU-T E.164-Sup.2]; : E.164, .

: (NNP), , / . .

URI tel: URI tel E.164 . URI, SIP , (NTP) /.

; ; **(DN):** , E.164, . , (CLIP) (COLP), / - .

1.1.6.1

, , E.164.

: () (TC), / .

(CC): , , , .

[ITU-T E.164]: , , E.164.

(MCC) [ITU-T E.212]: MCC IMSI (), . MCC. MCC 90x .

(NDC): , , (" E.164"), (SN) () E.164 . NDC (-), (, ,)//.

0 [N(S)N]: E.164, . () (NDC), , (SN). NDC SN, N(S)N SN. N(S)N .

0: , , , .

: , , , /.

(SN): E.164, - .

(TC) [ITU- E.164]: , (), (, ,). , . NDC.

1.1.6.2 ,

: , , , , .

: , . , , , -, .

[ITU-T E.212]: (, /), , .

: , (NDC) .

[ITU-T E.212]: , .

,: , () () (, 1XX).

: , , .

: , , , , .

- E.164 , :

- ,
- ,
- ,
- (GoC)
- .

, .

1.1.6.3 - E.164

, - E.164 [ITU-T E.190] [ITU-T E.164.1].

1 (, , ,). 1 3 .

0

-, () , N(S)N, 15 - n, n- .

N(S)N, (7 "" -). , N(S)N (NDC), (SN). NDC SN .

NDC () , . NDC :

a) (DN), , ;

b) (TC);

c) (DN) (TC).

NDC , .

DN-TC TC-DN . NDC (TC/DN) [1.9](#):



1.9 – E.164

:

CC – ;

NDC – ;

SN – ;

n – .

- E.164 .

- E.164

0

0 N(S)N., 0 . , , 0 , N(S)N. -, . - "" , : " 0 ". -, , , , 0. , , N(S)N. :

- 0, , ;

- ;

- , .

, N(S)N (0).

[ITU-T E.123] - E.164, .

. , :

a) ;

b) , ;

c) N(S)N SN, , , .

, , . (,), .

, , 0 , 0 9.

, (,), .

. , , .

: , , - E.164. (NDC) , (TC) / . (NDC).

, , :

- N(S)N ;

- N(S)N ;

– N(S)N .
 , , N(S)N, :

a) , ;

b) , .

1.1.6.4 - E.164

. - E.164 , [ITU-T E.190] , , [ITU-T E.164.1]. , , , , [ITU-T E.168] « E.164 UPT».

- E.164 , , (GSN). 15 (. 1.10).

. .

(GSN) , . , , [ITU-T E.169] « . E.164 , ».

. , , CC + N(S)N. , , , .

- E.164

, , (SN) (GSN). , - . , , [ITU-T E.169] « . E.164 , ».

1.1.6.5 - E.164

, - E.164 [ITU-T E.164.1] [ITU-T E.190].

- E.164, , : - E.164 , (. 1.11). - E.164, , (15) .

– - E.164 . – , .

(IC) – , 1–4 , . - E.164 .

– , IC. . 15 CC IC. :

– IC;

– IC;

– IC;

– IC.

, , , , CC + IC, , 10% , .

, - E.164 , , , , - E.164, () . IC, .

1.1.6.6 - E.164

, - E.164 [ITU-T E.164.3] [ITU-T E.190].

- E.164, , : - E.164 ; , – (. 4 - .164 [4]). - E.164, , 15 .

- E.164 . – (GoC) CC, GIC .

(GIC) – , . GIC - E.164 .

(SN) – (), CC + GIC GoC . , 10% , CC + GIC, GoC, , . GoC, – (GICA).

- E.164 , , . CC (), GIC (), (SN). (CC + GIC), .

-, , , , , (), 002.

[ITU-T E.123] "+" , .



1.10 – E.164

:

CC – ()

GSN –

-.164 .



1.11 – - E.164

:

CC – ()

IC –

SN –

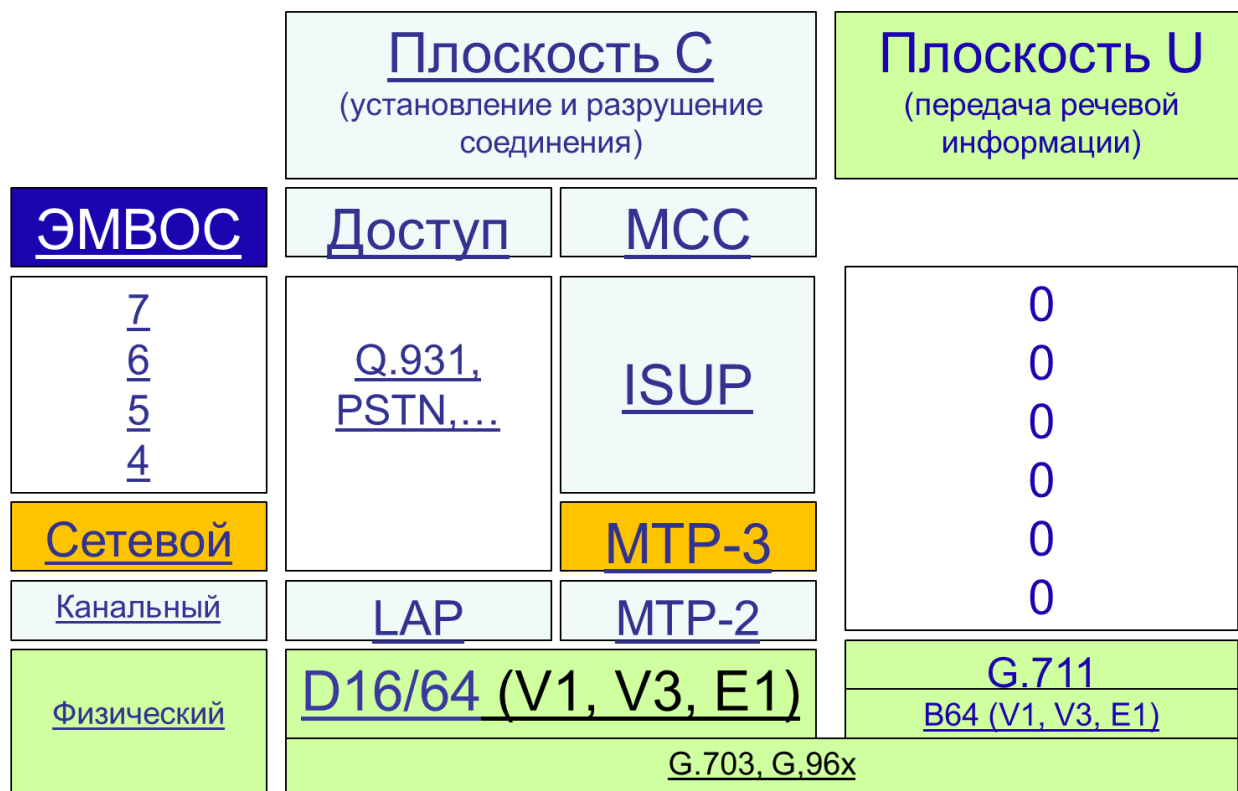
x –

-.164 .

1.1.7 (U,,)

, , , OSI (,).

/ISDN TDM-:



1.12 – /ISDN TDM-

, 1.12, () , 0.
(G.711, G.703, G.704), 64 /.

2 VoIP

2.1 IP-

() 70- 20-, , ().
– 1993 .
:
• (10 / 155 /);
• , , , 100...150 (end-to-end) 1...2 ;
• ;
• , .
1993 . () ().
1995 , VocalTec () Internet Phone, .
1995 . , , .
1996 . "Internet Telephone Gateway" : VocalTec Dialogic. , , VTG (VocalTec Telephone Gateway). 11 /.
– .
1997 . , . IP- , , :
• , ;
• , IP- .
IP (VoIP) , , .
, IP-, , .

2.2

1. , :
- (1...2 1 - 5 1);
 - (1 %);
 - (= 0,99999) , - SDH;
 - .
1. ().
2. , (64 /).
1. TDM- G.711(64/), , (32 / 8 /).
2. (, , ..) TDM- :
- (2 / 34 /);
 - (10^{-5} 10^{-8});
 - , , ..- =V/V 200!
1. 64 / TDM , (, , ..) 32 /, 16 /, 8 /, 6,4 / . 8 / TDM 64 / - ! (!!!)
2. , TDM- (, Ethernet).
3. TDM (, ,).
4. (, , dial-up) (), - , (- ARPU -).
- IP-, IP- , IP- .

IP- :

1. TDM-.
- .
 - (250...400).
 - (30...50) .
 - .
1. (-).
2. (,).
3. IP-, , .
4. . IP- (, IP-, , , IP-).

IP- , :

1. (TDM-).
2. IP- , NGN/IMS:
- .
 - IP- (, Web, E-mail, SMS/IM ..) (, Skype, Google+, VK ..), .
 - IP- , (ARPU), IP- , TDM-.
 - IP- , TDM-, IP-, IP- .

IP- - , .

, - IP- (, ,).

IP-, SIP, IP- .

, .323 IP- IP . H.323 , TDM-.

«» «», IP-, - MGCP, MEGACO/.248. IP- - .

-IMS, IP- , SIP. SIP IT-. SIP .

«» , , IP- . MGCP, MEGACO, , .

, IP- - . IP- (, ,). IP- , , -.

, IP- .

2.3 NGN

, 1...2 , .

80- / (N-ISDN -), , , 128 /, 4-, , 2 /.

N-ISDN ITU-T , , :

- (TDM-),
- N-ISDN , - TDM-,
- N-ISDN , (PDH/SDH) , , , 128 /.

80- 20- , , 1 / .

(, N-ISDN), , TDM-.

N-ISDN (), , NGN, :

- 7 ISUP, NGN ;
- BRI PRI DSS1, NGN ;
- (Bearer services) (teleservices), NGN .

-7 INAP (IN).

(SCP) (SSP) IN Softswitch () NGN.

NGN .

1992 1998 (), (B-ISDN -), :

- /B-ISDN , , 1992 1998
- /B-ISDN (, , GSM-2G). IP-.

/B-ISDN, NGN (Y. ITU-T):

- - ();
- (,);
- , NGN.

, /B-ISDN , Ethernet, - Ethernet-, «» , IP/Ethernet.

, N-ISDN, IN, B-ISDN/ATM (GII) NGN (Next Generation Network) – (). ITU-T Y.100...Y.3xxx.

, NGN IMS (IP Multimedia Subsystem IP-) 3GPP ETSI 3GPP2.

NGN IMS (,), :

1. **NGN** ITU-T «-» – . NGN (, , Softswitch). , . Softswitch AS () () «800», «803», «809» .., AS NGN – SCP (IN).

2. **IMS** 3GPP ETSI «-» – , , . , .

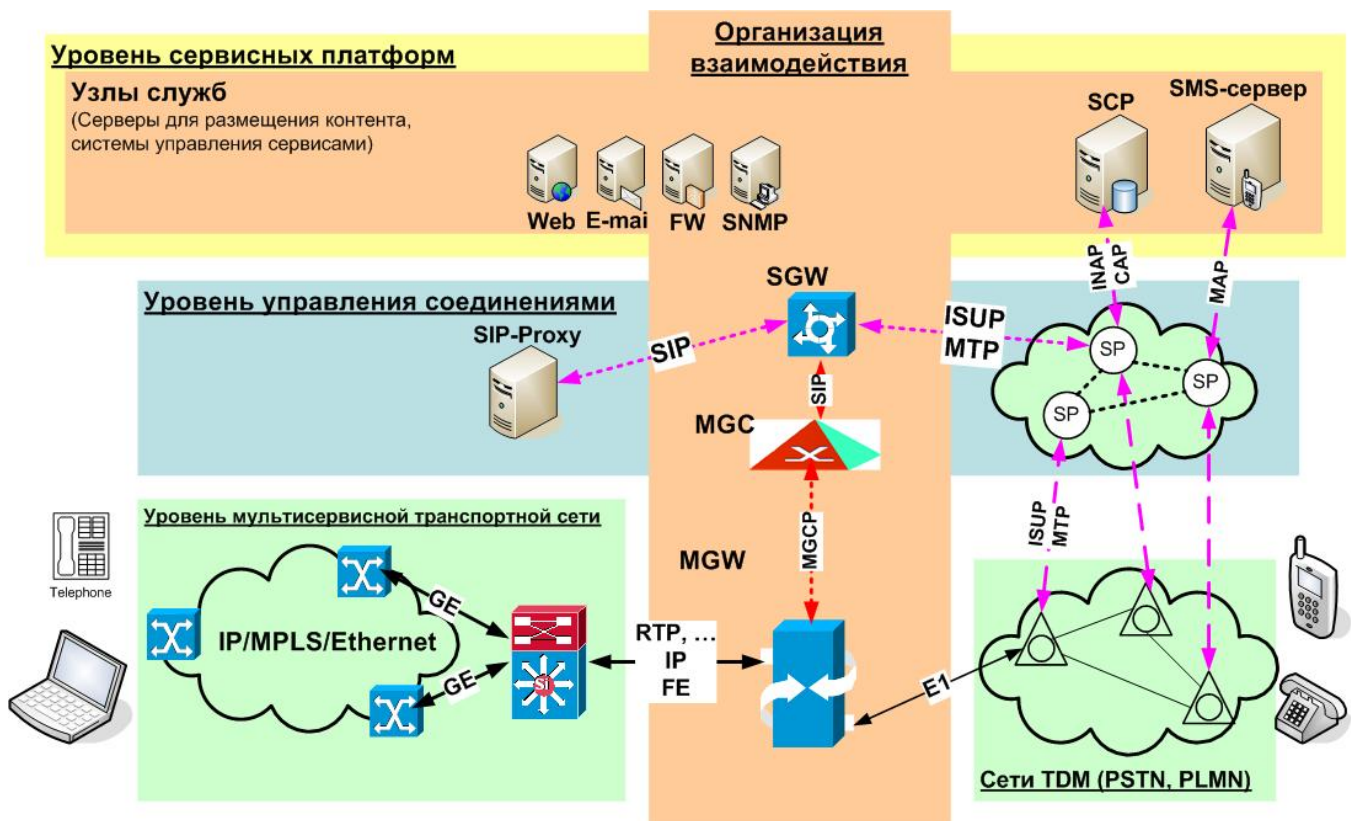
IMS , (SMS, MMS, , ..).

(,), . IMS (IP/MPLS/Ethernet), NGN, (Softswitch) , , IMS 2G (MCS, HLR/VLR, AUC), 2,5G (SGSN), 3G ..

NGN, :

- NGN Softswitch, [9]:
 - MGC – , (Call-Server);
 - MGW – , () (, , 25 ..) , IP-;
 - SGW – , SIP, NGN/IMS;
 - SIP-proxy/ SIP, NGN/IMS, /GSM;
 - AS – , (-);
- (MGCP, H.248/MEGACO), NGN , , .

, NGN (, FR, , GSM, ...) NGN Softswitch (. 2.1):



2.1 – NGN , GSM -7

TCP/IP

, dod (), , .
IP (4 6), TCP UDP.
– -7, TCP/IP NGN:

2.1 –

OSI	-7	TCP / IP	NGN
	MAP, INAP, CAP	HTTP, SIP, SNMP, ...	
	TCAP		
	SCCP	TCP-UDP	
	MTP-3	IP	
	MTP-1	Ethernet, ATM, FR, ...	
	E1		

, OSI () – . - ., Ethernet – (hubs), 3-, , , .
– NGN OSI. , , , , L4,, .

2.4 IP-. , ,

2.4.1 IP

IP-. 5 IP-, :

2.2 – IP-

	IP-				.
A	0	0.0.0.0	127.0.0.0	$2^7 - 2$ (126)	$2^{24} - 2$
B	10	128.0.0.0	191.255.0.0	$2^{14} - 2$	$2^{16} - 2$
C	110	192.0.0.0	223.255.255.0	$2^{21} - 2$	$2^8 - 2$ (254)
D	1110	224.0.0.0	239.255.255.255	15×2^{24}	(multicast)
E	11110	240.0.0.0	255.255.255.255	7×2^{24}	

WAN – , .

RFC 2050 IANA IP-.

ARIN, RIPE APNIC, IP- .

2003 , IP, , .

- IP-:
1. IP- (,).
 2. / / .
 3. / / .
- 1995 . IPv4.
- :
1. .
 2. (,).
 3. .
 4. IPv4 .
- :
1. NAT, 4- (TCP-UDP).
 2. IP-, «» .
 3. CIDR, IP-.
- .

2.4.2 IP. NAT

1999 IETF RFC 2663 , **NAT**. NAT – «» 4- (TCP UDP), OSI – () .

(«»):

2.3 –

A	10.0.0.0 — 10.255.255.255	/ 8
B	172.16.0.0 — 172.31.255.255	/ 12
C	192.168.0.0 — 192.168.255.255	/ 16

NAT- /UDP- IP-/UDP-.

2.4.3 . IP-

«» .

– , , , , – .

IP- «», , – ().

, 32, , .

"/" , 192.1.1.0/25 192.1.1.0 255.255.255.128.

IP-, .

: **192.168.5.0** (/24).

: 192.168.5.1 192.168.5.**254** (254).

– /25, /26, ..., 24!

/

1. /24

IP- : 192.168.5.143,

RT: 255.255.255.0 /24

: 192.168.5.0

192	168	5	143
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	1 0 0 0 1 1 1 1
Производим побитное умножение (логическое И) :			
255	255	255	0
1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0
Получаем результат:			
192	168	5	0
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	0 0 0 0 0 0 0 0

2. /25

IP- : 192.168.5.143, RT: 255.255.255.128 /25.

192.168.5.128:

192	168	5	143
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	1 0 0 0 1 1 1 1
Производим побитное умножение (логическое И) :			
255	255	255	128
1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 0 0 0 0 0 0 0
Получаем результат:			
192	168	5	128
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	1 0 0 0 0 0 0 0

IP- 192.168.5.76 /25 (255.255.255.128) 192.168.5.0:

192	168	5	76
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	0 1 0 0 1 1 0 0
Производим побитное умножение (логическое И) :			
255	255	255	128
1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 0 0 0 0 0 0 0
Получаем результат:			
192	168	5	0
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	0 0 0 0 0 0 0 0

CIDR . **CIDR** (Variable Length Subnet Mask — **VLSM**), , () (/0, /8, /16, /24).

«n, », :
11111111.11111111.00000000.00000000
255.255.0.0 /16, :
172.24.0.210/16
 VLSM , , , .

500 . () – 254 , – 65 534 . .
 CIDR/VLSM 512 :

1	1	1	1	1	1	1	1	.	1	1	1	1	1	1	1	1	.	1	1	1	1	1	1	1	0	.	0	0	0	0	0	0	0	0					
– 255.255.254.0 /23																																							

2.5 IP-

(QoS) :
 • ;
 • 0;
 • ;
 • ;
 • .
 , – .
 () ().
 , – .
 , 0 .
 :
 • (,),
 • (),
 • (–).
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- 0;

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- (), , ;
- (), () .

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- ;
- 0 .

(- RT) .

:

- - (DVA – Distance Vector Algorithms) – -;
- (LSA – Link State Algorithms) – ;
- 0 – , , .

DVA – RIP (Routing Information Protocol).

DVA (), .

DVA . , (15).

, .

– , .

, , .

, .

LSA.

, .

, .

() () .

LSA OSPF (Open Shortest Path First).

, OSPF, IS-IS, .

.

, , .

, , .

, .

(NGN) , , , .

, Ethernet.

2.6 Ethernet

Ethernet (L2).

L2 , L2. L2 .

L2 , , - , L2 .

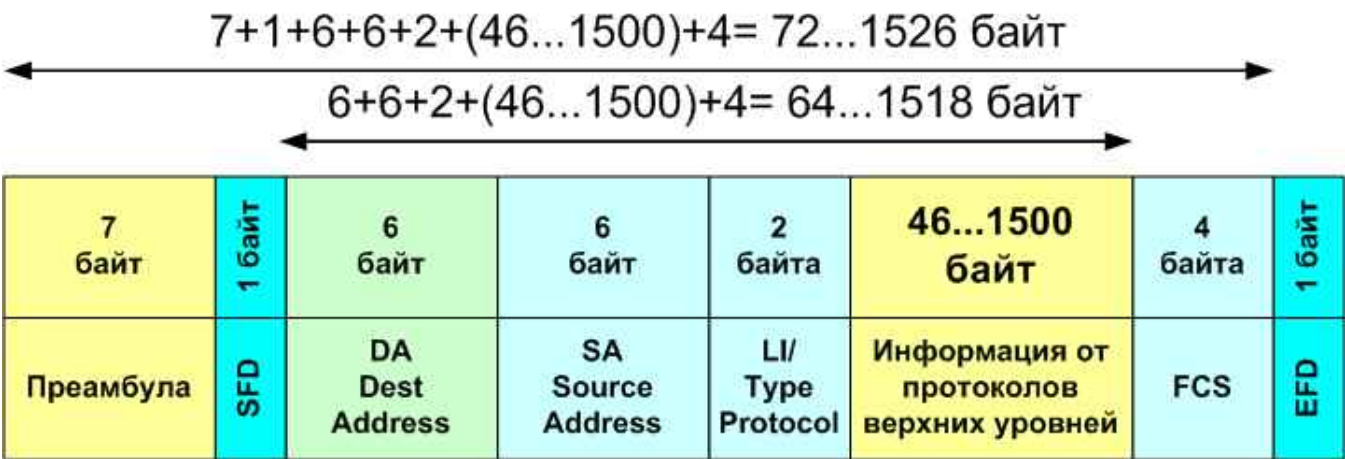
L2 , HDLC, LAP-D, Ethernet, ATM, , Frame Relay . Ethernet.

2.4 , OSI, - Ethernet , -.

2.4 – – L2

OSI	- Ethernet	Ethernet
		LLC, 802.1p/Q, MPLS .
/ ()	()	802.1p/Q, MPLS .
	SFD/EFD	-
	Ethernet .	LLC, 802.1p/Q, MPLS . L2.
	FCS.	-
		LLC , .
	FIFO, .	802.1p/Q, MPLS . CoS, L2 .
	(,).	. LLC, 802.1p/Q, MPLS, SNMP .

2.2, Ethernet, (Frame).



2.2 – Ethernet ()

– 7 . – 10101010. . , «» L1. , Ethernet L1, Ethernet .

SFD/EFD – / () 10101011. , Ethernet L2.

DA – – 6 . =0, , =1, . (broadcasting) 1 (FF:FF:FF:FF:FF:FF).

SA – – 6 . - 0.

3 MAC- , (OUI - Organizationally Unique Identifier) [5]. :

00 20 AF – 3COM.

A8 F9 4B – Eltex, Novosibirsk, RF.

3 MAC- , , .

(LI)/ (TP EtherType) – (IEEE 802.3 1500). =>1500 – (Ethernet II).

2.5 .

2.5 – , Ethernet

EtherType (TP)	Protocol
08 00	Internet Protocol, Version 4 (IPv4)
08 06	Address Resolution Protocol (ARP)
80 35	Reverse Address Resolution Protocol (RARP)
81 00	VLAN-tagged frame (IEEE 802.1Q, 802.1aq)
81 4C	Simple Network Management Protocol (SNMP)
86 DD	Internet Protocol, Version 6 (IPv6)
88 47	MPLS unicast
88 48	MPLS multicast
88 63	PPPoE Discovery Stage
88 64	PPPoE Session Stage
88 A8	Provider Bridging (PBB – IEEE 802.1ad, 802.1aq)
88 AB	Ethernet Powerlink
88 F7	Precision Time Protocol (IEEE 1588) (Ethernet)
91 00	Q-in-Q

46 1500 . 46 , , 46 .

FCS – – 4 . Ethernet CRC-32. = 1/2³² = 10⁻⁹.

2.6.1 Ethernet

Ethernet:

- ;
- (98% LAN, 95% MAN);
- ;
- , IP;
- Ethernet L2 (, ,) L1 ();
- (10 /), Metro () .

2.6.2 Ethernet

, Ethernet :

- Ethernet QoS;
- BW ();
- (CoS,);
- Ethernet , , (TDM-, , , PLMN);
- Ethernet «» (=99,999), “ring” “mesh”;
- Ethernet (), , (L3), .

(MPLS, RPR, IEEE 802.1p/q), Ethernet.

2.7 VLAN

Ethernet-, , , , .
(VLAN) , , , , VLAN.
, , VLAN, - ().
VLAN .
, , . () VLAN, VLAN.
, , .
, Ethernet- , **Ethernet** Ethernet.

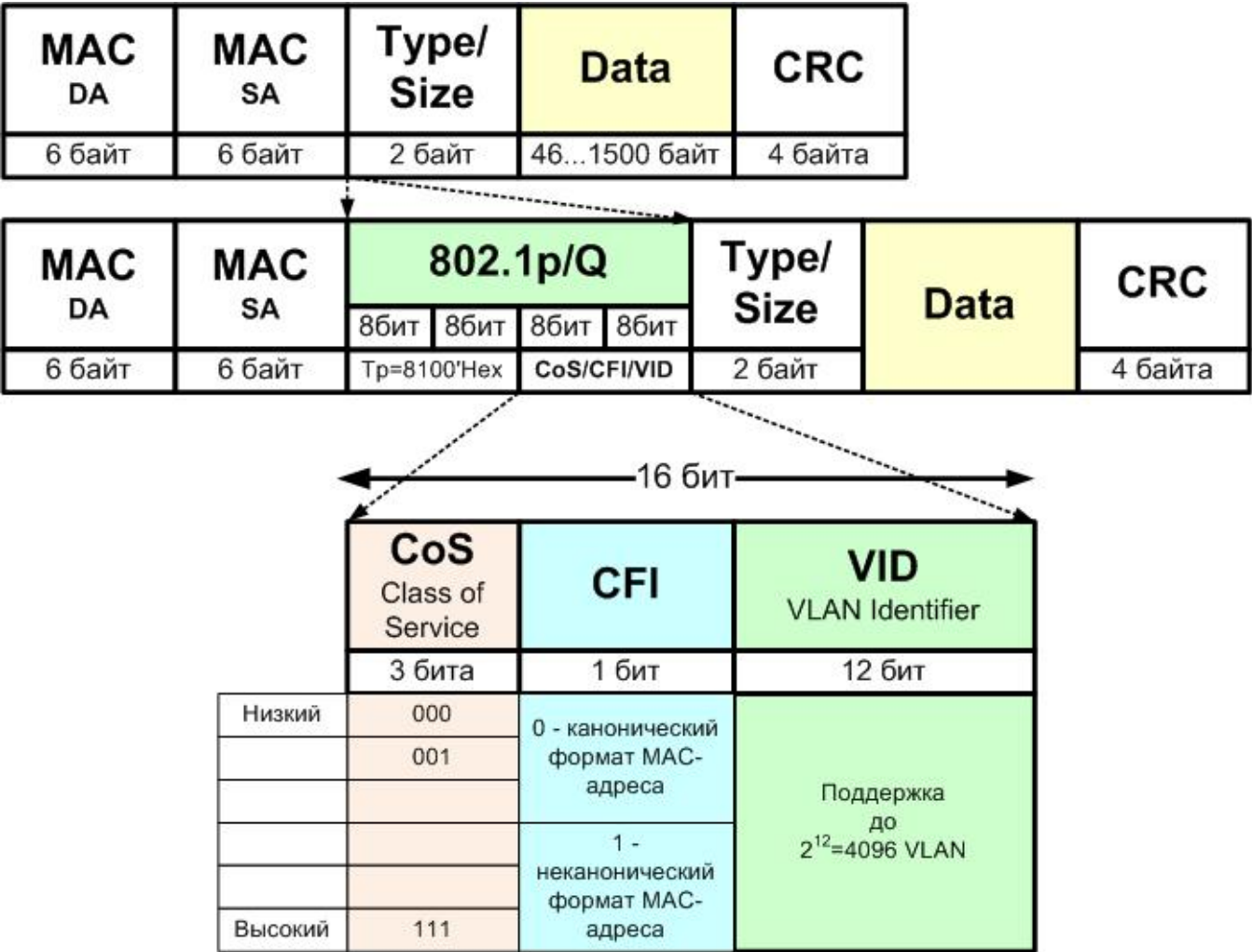
VLAN/QoS:

- 1. () :
 - Ethernet (PPPoE);
 - VPN – 802.1Q (VLAN), MPLS, PBB.
- 1. () .
- 2. .

QoS PPP/Ethernet/ATM VLAN, DHCP, xSTP, MPLS ..

VLAN IEEE 802.1 p/Q.

IP- Ethernet , (802.1p/Q), 4 :



(802.1p/Q) TPID (Tag Protocol Identifier, = 8100'Hex) TCI (Tag Control Information), CoS (Priority), CFI VID.

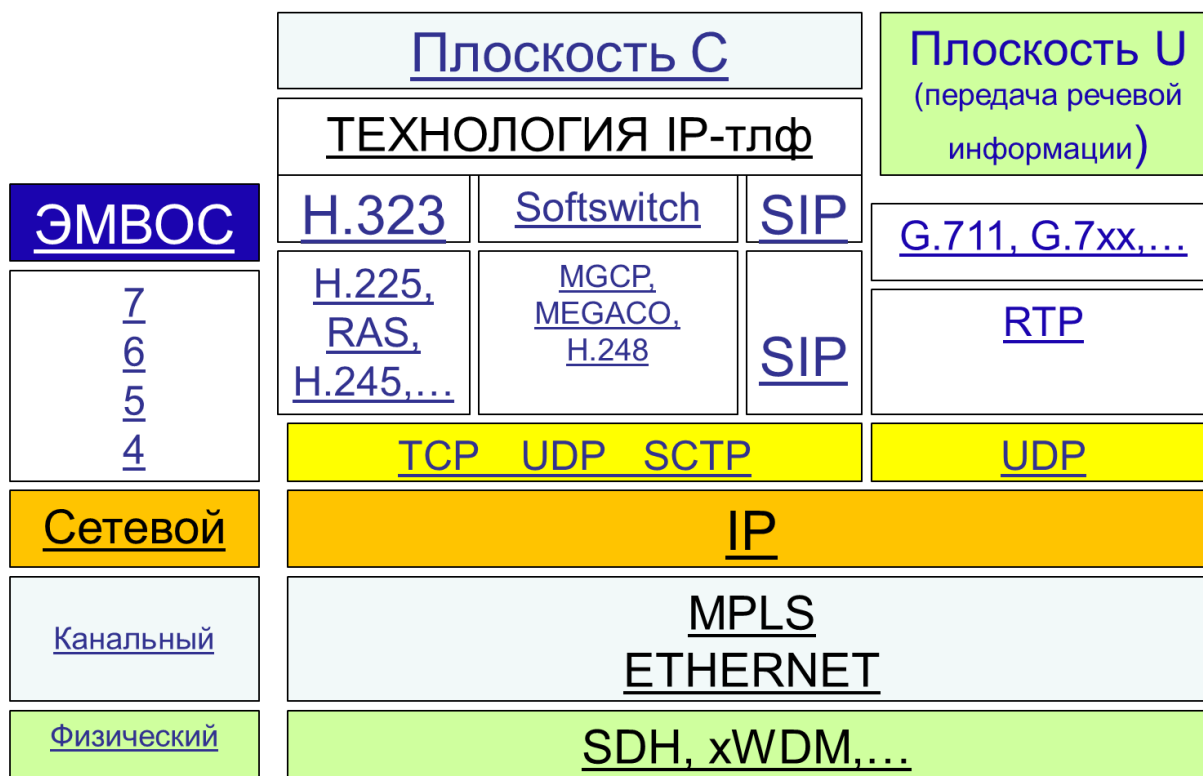
CoS (Priority) 3 () .

VID (VLAN ID) 12 () . 12 4096 , 0 4095 , 802.1Q 4094 .

CFI (Canonical Format Indicator) 1 (Token Ring, FDDI), Ethernet, Ethernet 0.

2.8 VoIP

TDM-, IP- () / , (. 2.4):



2.4 – IP- (H.323, MGCP, MEGACO/H.248, SIP) , (U): G.xxx, / RTP / UDP / IP / MPLS / (L2 , Ethernet)

IP- C, .

2.8.1 H.323. .

IP- ITU-T H.323.

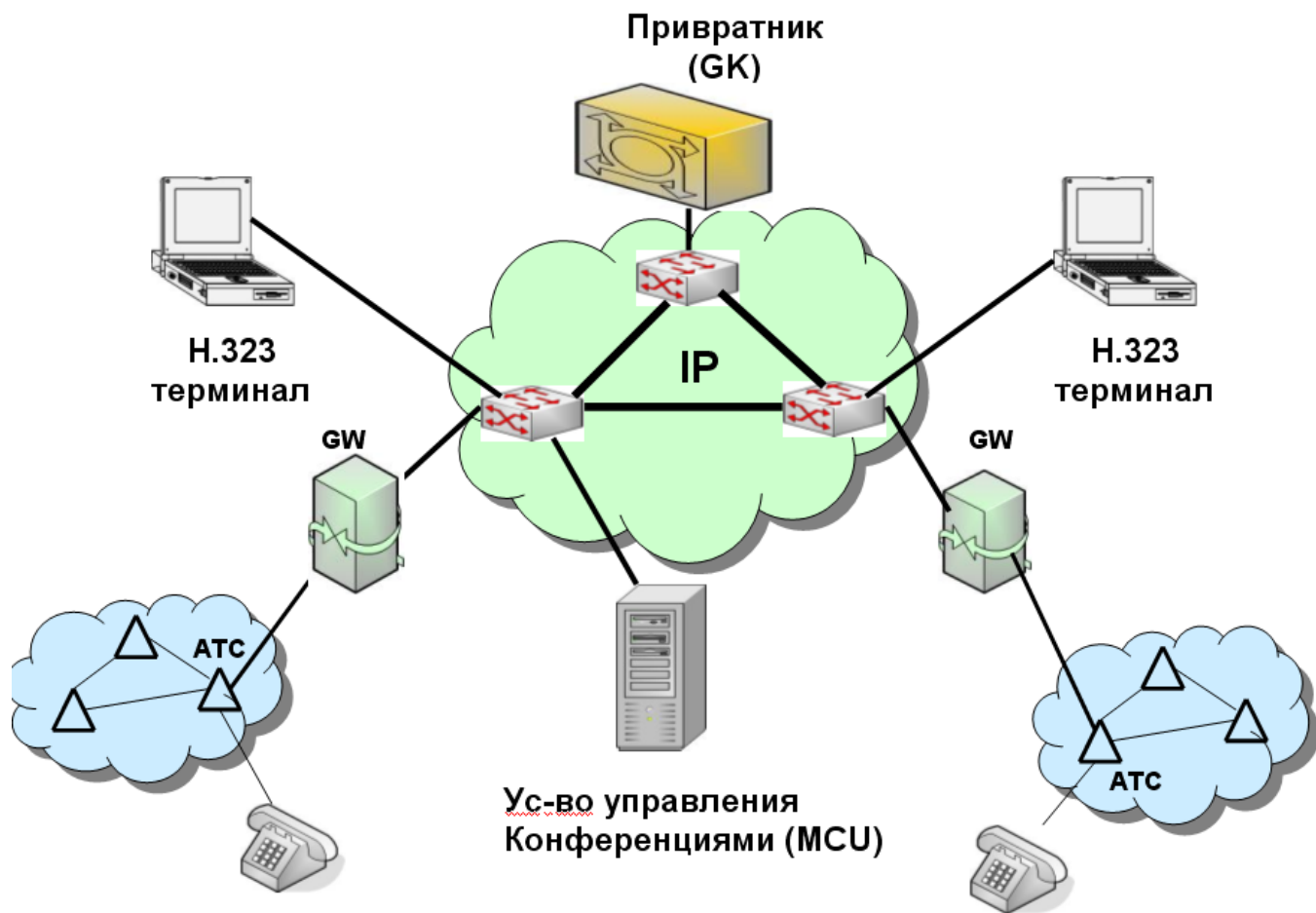
H.323 , , .

2.8.1.1 H.323

.323 . , IP- Q.931 , ISDN.

, ITU-T .323, , , IP, VoIP.

.323 2.5:



2.5 – .323

, IP- .

, - .

IP- H.323 :

- .323,
- .323 (Gateway – GW),
- (Gatekeeper – GK)
- (Multipoint Control Unit – MCU)

2.8.1.2 H.323

.323

.323 – IP-.

(PC) IP-, H.323.

.323 () .323, .

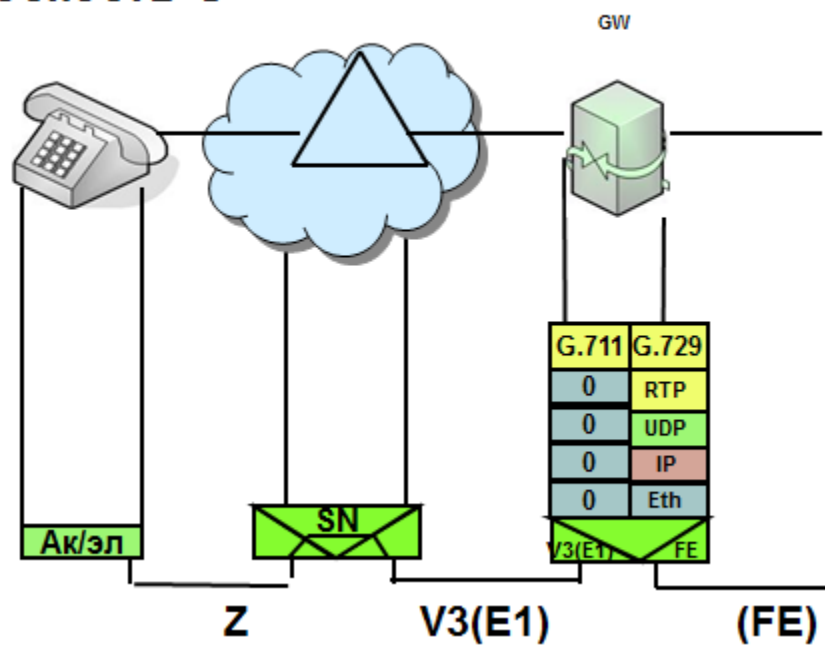
, H.323 NetMeeting Microsoft Windows'95/98. H.323 , IP- .

.323 (GATEWAY – GW)

H.323 , TDM () VoIP. (, diap-up), () , IP (H.225, RAS, H.245).

.323 : , (TDM-), , IP. [2.6.](#)

Плоскость U



2.6 – .

(DSS1, -7 (ISUP), R2,...) .225 (Q.931) .

(GATEKEEPER – GK)

VoIP .323.

:

- , ;
- IP- RAS;
- (, .) IP- (IP- + TCP);
- , IP-;
- .225 H.323.

IP- .323, , RAS.

() , RADIUS.

– MCU

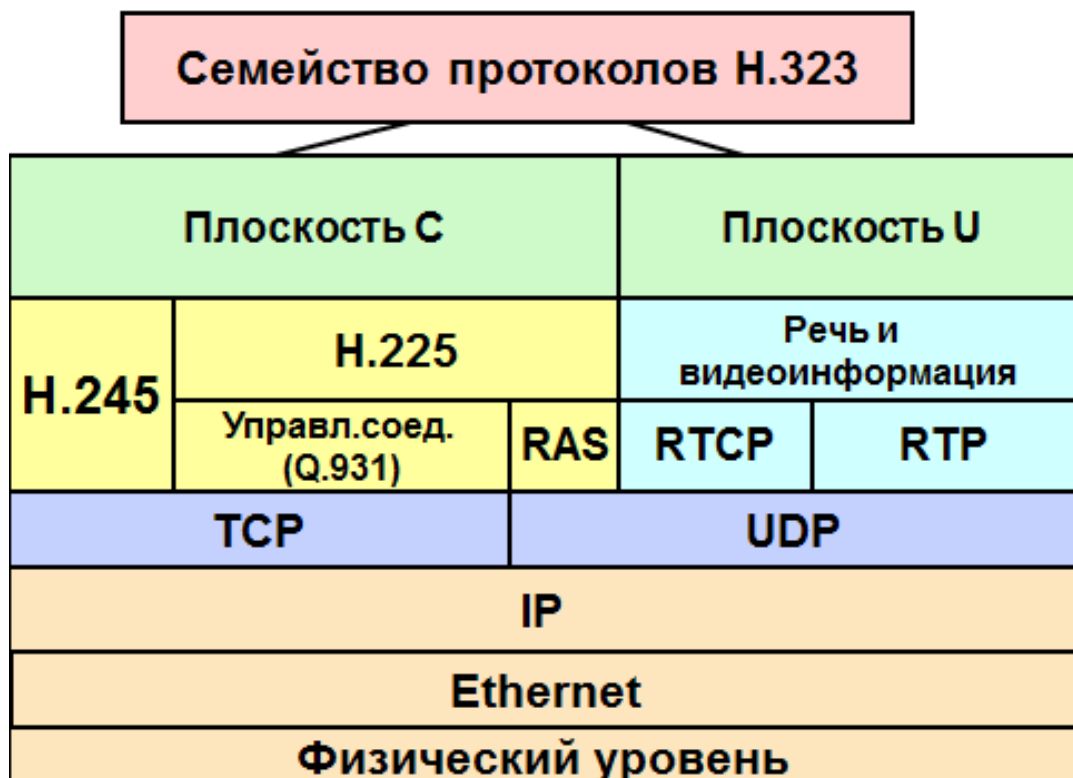
MCU .

.323 :

- (-),
- (-)
- .

2.8.1.3 .323

.323 , 2.7 (IP-).



2.7 – .323

U (user) .

(control) .

, .323.

1. RAS (Registration Admission Status), .

:

- H.323;
- ;
- ;
- ;

UDP.

2. .225.0 (Q.931) , IP-. Q.931, , , , .

.225 :

- SETUP – ;
- CALL PROCEEDING – ;
- ALERTING – ;
- CONNECT – ;
- DISCONNECT – ;
- RELEASE – ;
- RELEASE COMPLETE – .

TCP.

3. .245 IP- H.323, , , , RTP/UDP/IP, .225.

, RAS, .323.

.225.0 (Q.931) .245.

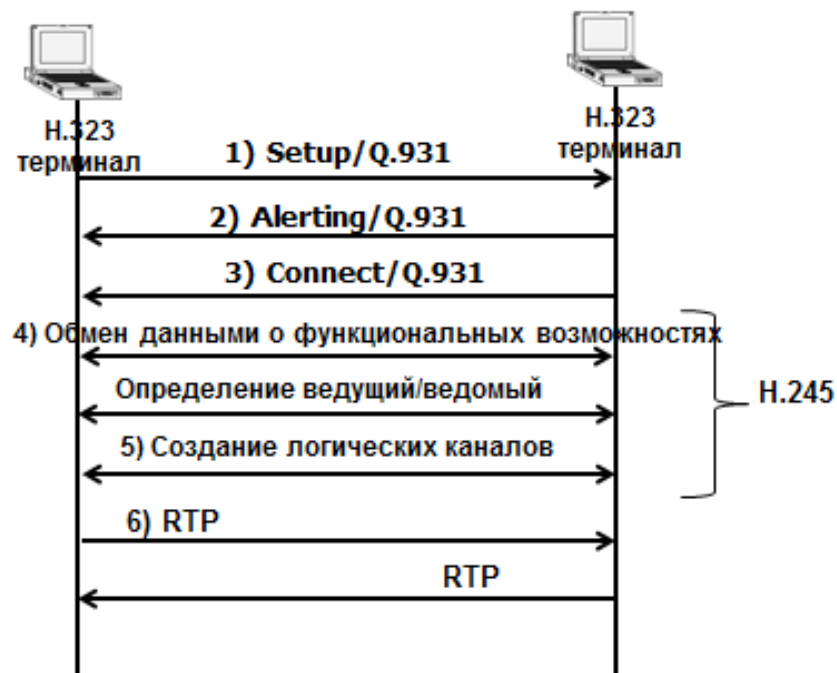
:

- .245 .225.0,
- RAS .

2.8.1.4 IP-

(. 2.8).

, IP- , .



2.8 – .

- SETUP - - 1720.

SETUP ALERTING, , , .

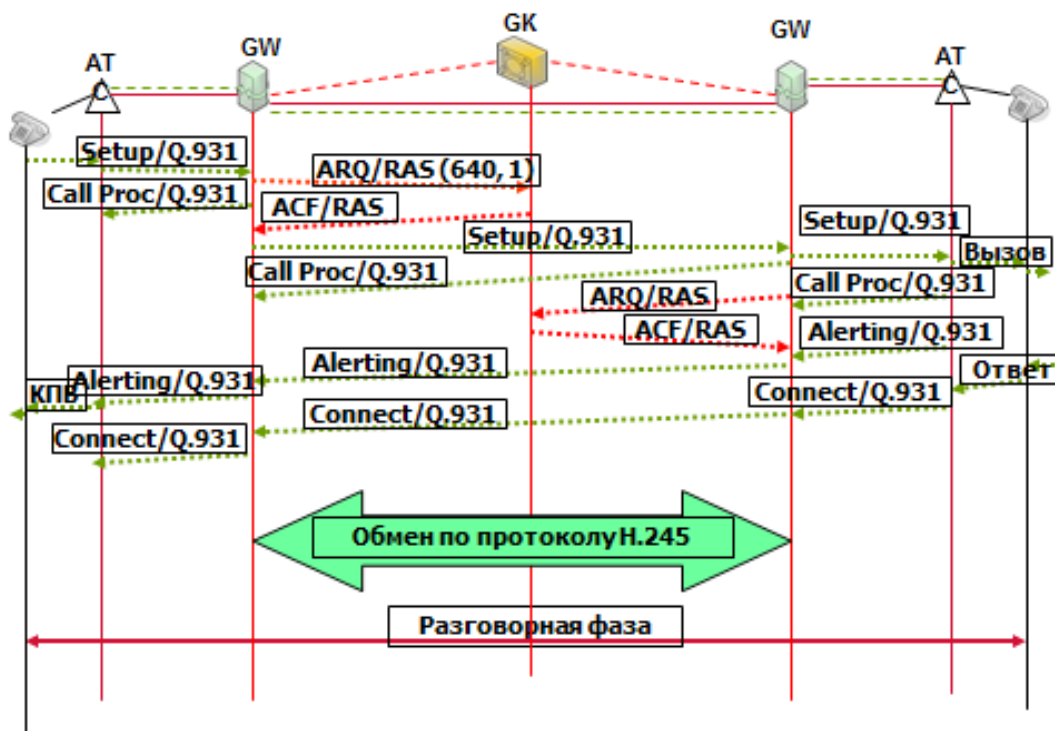
, , CONNECT - .245.

.245 (G.729, G.723.1 ..), , RTP, .

RTP, , RTCP.

. . (. 2.9), IP- .

, .



2.9 – .

, (Setup) Admission Request (ARQ) , .

ARQ , ARQ, , . alias- .

ARQ RTP/UDP/IP .

, Admission Confirm (ACF). .

ACF Setup .225.0.

, Admission Reject (ARJ).

, RAS, :

- ;
- ;
- ;
- ;
- ;
- ;
- ;
- ;

H.323 , .323, Softswitch .323 Softswitch.

2.8.1.5

1. .323.
2. IP-, .
3. Q.931 IP-, .
4. -7 IP-, .
5. .323 U.
6. .323 C.
7. Q.931.
8. .
9. .

2.8.2 SIP. .

2.8.2.1

IP- SIP.

() , , .323, , IP- T, .

SIP IETF – , , TCP/IP. SIP , HTTP: – (request – reply). SIP , .

SIP Session Initiation Protocol – , SIP , , : , , , , .

SIP :

- ;
- ;
- ;

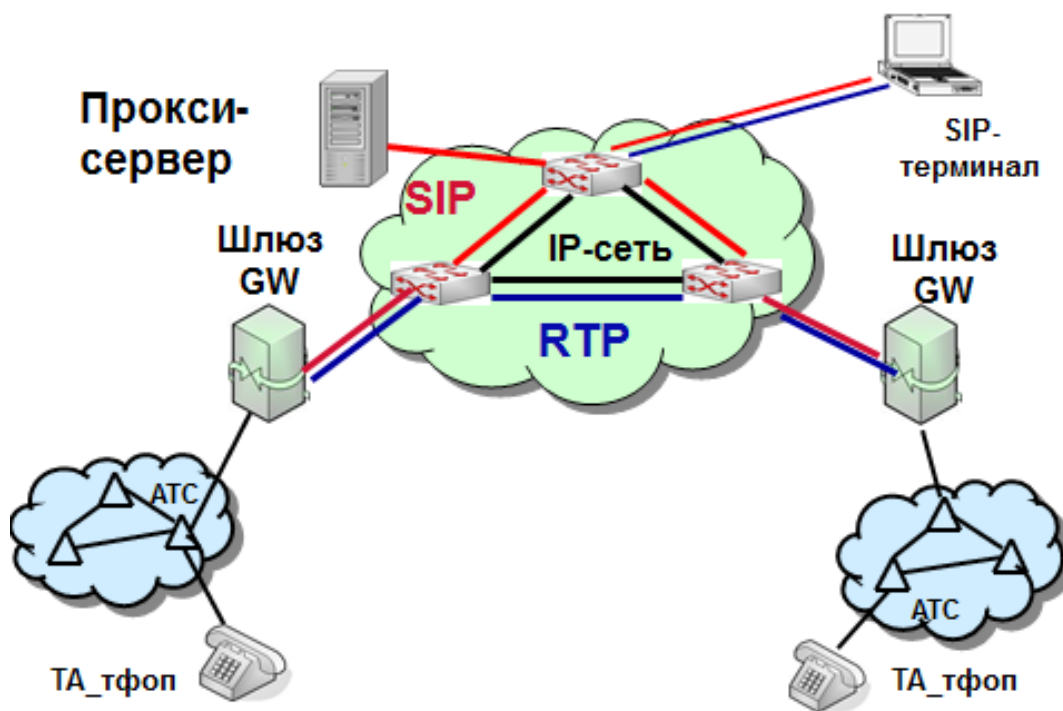
SIP SIP (SDP, ISUP, Q.931, ...).

, SIP- SIP SDP (Session Description Protocol –), SIP . SDP *SIP*.

SIP 3GPP, IMS, 4G.

2.8.2.2

SIP [2.10](#).



2.10 – SIP

SIP-, SIP-, – , , .

SIP- . , SIP- , Softswitch, SIP-T (ISUP SIP).

- (proxy -)

, , , , : , , , .

. , , .

(SIP).

REGISTER

SIP

SIP – IP-.

(PC) IP-, SIP.

SIP SIP, proxy-.

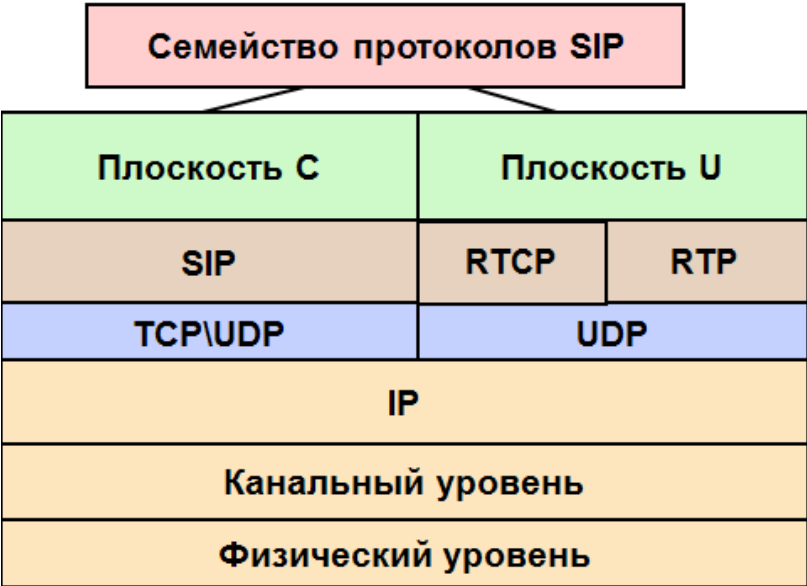
SIP

IP- SIP :

- , (TDM-), , IP;
- (DSS1, -7 (ISUP)) SIP .

2.8.2.3 U C

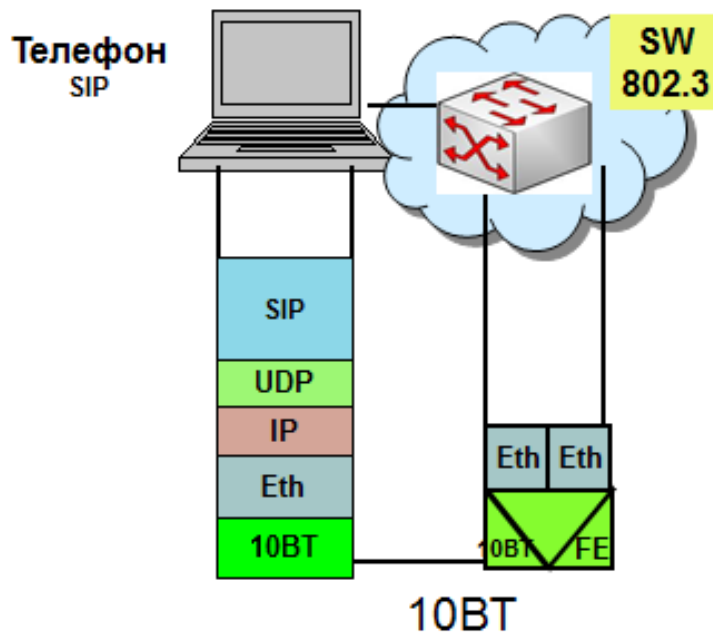
SIP . .25, Frame Relay, AAL5/ATM, IPX . SIP . IP UDP. , , , UDP, TCP. UDP , TCP, (), . , TCP (firewall), . TCP , , TCP-, TCP-. 2.11 , SIP TCP/IP. , IP-, RTP.



2.11 – SIP

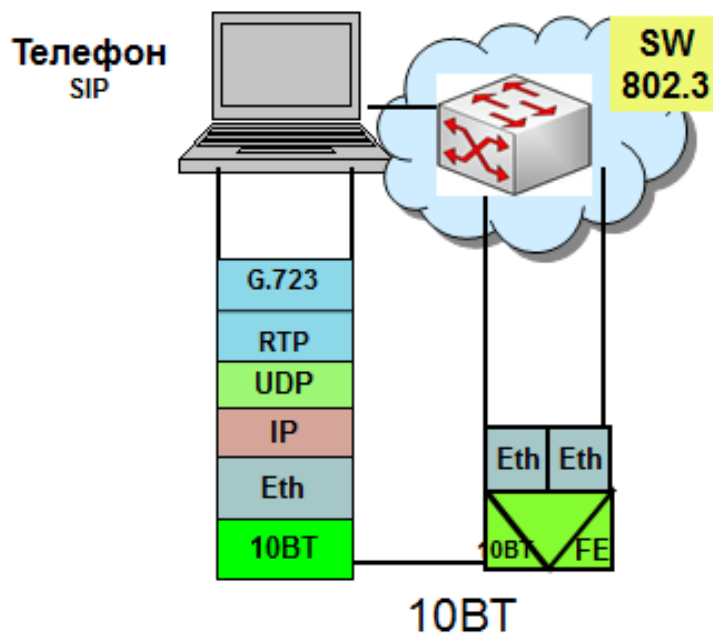
SIP – (2.12... 2.13).

Плоскость С



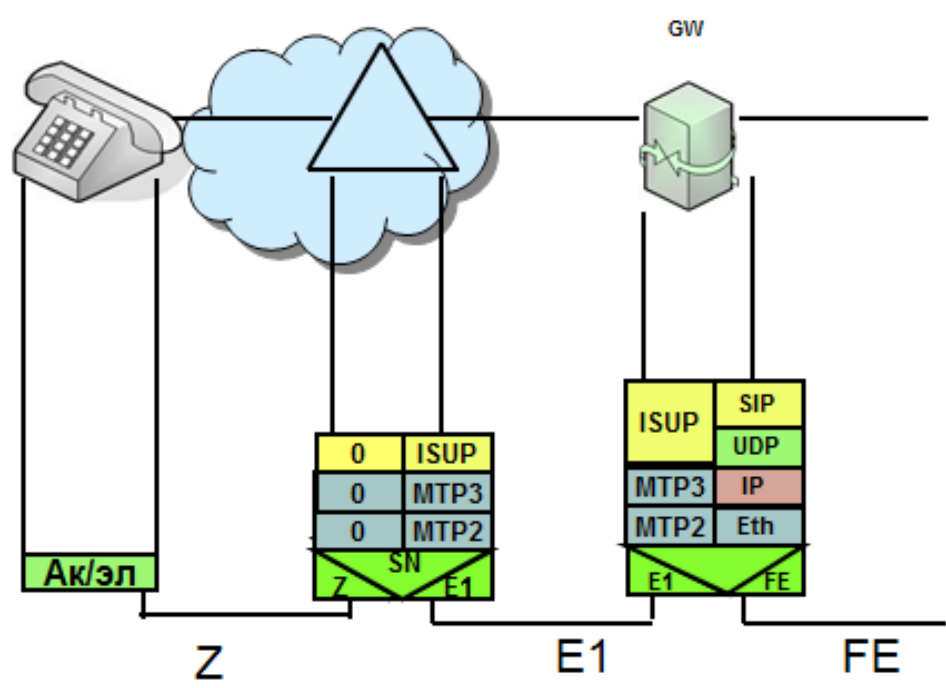
2.12 – SIP -

Плоскость U



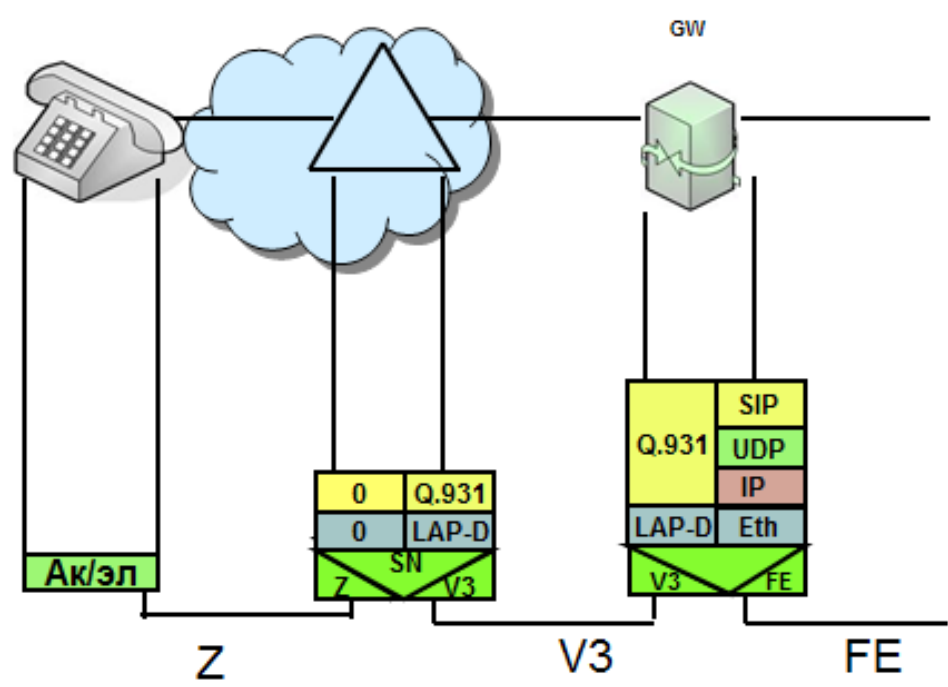
2.13 – SIP-

Плоскость С



2.14 – -7 SIP-

Плоскость С



2.15 – Q.931 SIP-

2.8.2.4 ,
IP- SIP , .

SIP - :

- @;
- @;
- @IP-;
- @.

: - , , . IP- – Domain Name Service (DNS).

SIP- «sip:», , SIP-.

:

sip: [123456@abc.eltex.nsk.ru](tel:123456@abc.eltex.nsk.ru)

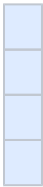
sip: [user@192.168.100.152](tel:user@192.168.100.152)

sip: [294-75-47@sip-gateway.ru](tel:294-75-47@sip-gateway.ru)

2.8.2.5 SIP-

«->» , , .

SIP () , RFC 2279.



2.16 – SIP –

SIP- , , . , , , .

, , , , , .

.

, INVITE OPTIONS . BYE . : , .



2.17 – SIP –

2.8.2.6 SIP-

SIP (RFC 3261)

- INVITE – . . . SDP-;
- – INVITE;
- BYE – . . . ;
- CANCEL – . . . Call-ID, , From CSeq, . . . ;
- REGISTER – . . . ;
- OPTIONS –

, SIP 8 , . . .

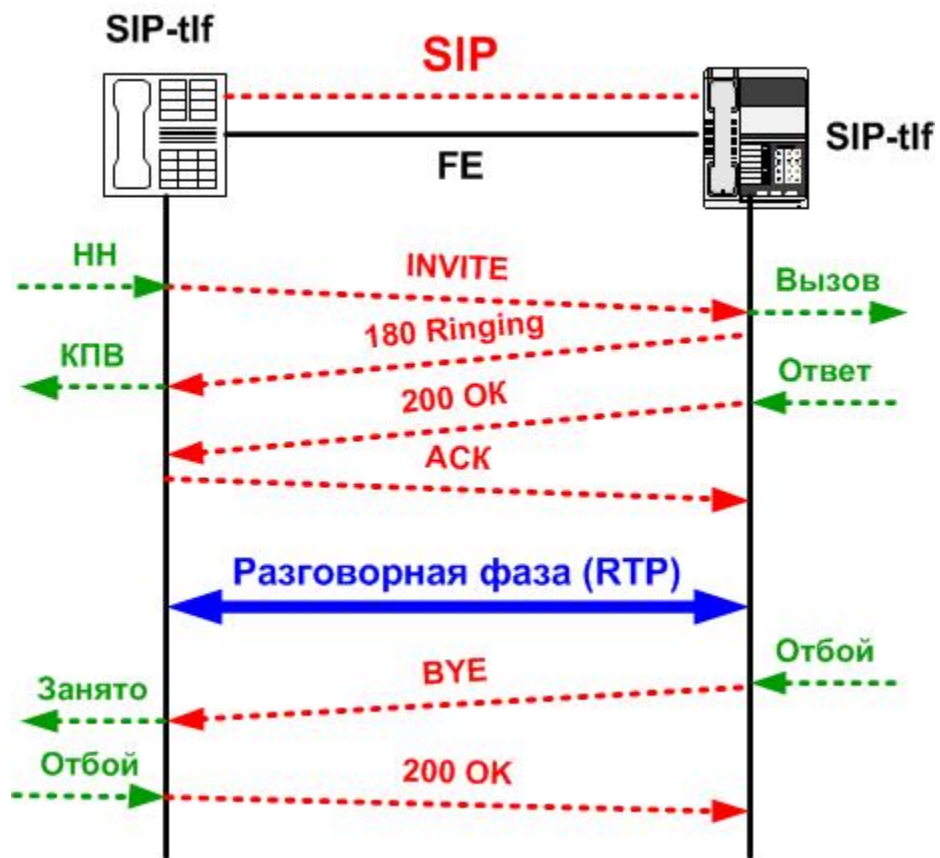
- PRACK – (RFC 3262);
- SUBSCRIBE – (RFC 3265);
- NOTIFY – (RFC 3265);
- PUBLISH – (RFC 3903);
- INFO – , (RFC 2976);
- REFER – SIP (RFC 3515);
- MESSAGE – SIP (RFC 3428);
- UPDATE – (RFC 3311).

SIP , 1, 2, 3, 4, 5 6.

- 1 – , . . .
- 2 – , . . . ;
- 3 – . . . ;
- 4 – , . . . ;
- 5 – , . . . - ;
- 6xx – ,

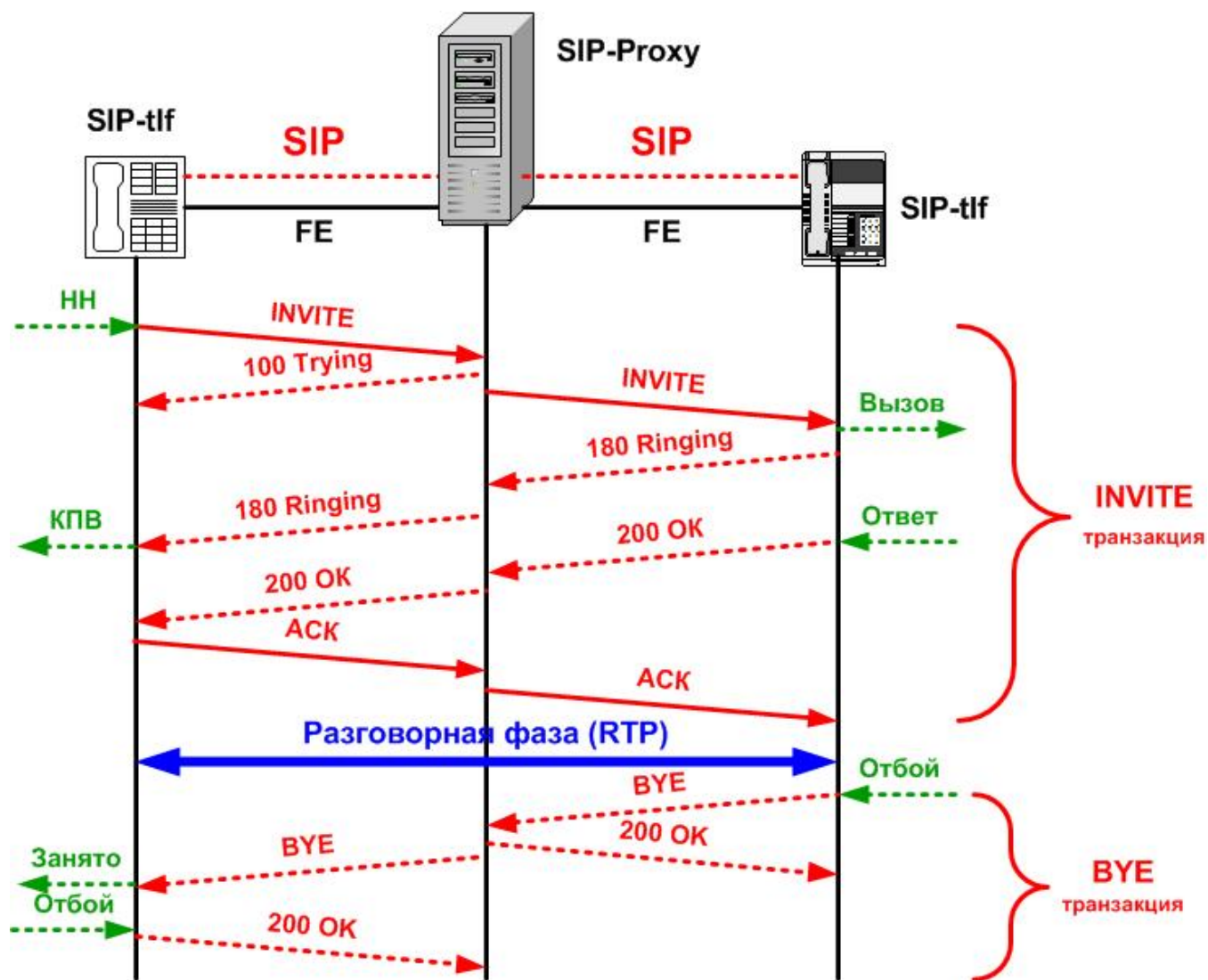
2.8.2.7 IP- SIP

1. SIP- SIP-.



2.18 – SIP-

2. IP- - 2.19 ():



2.19 – IP-

INVITE . INVITE - (. 2.19). . INVITE , - 100 (Trying), , INVITE .

-, , INVITE . , Via - , , 180 Ringing, INVITE , From, Call-ID, CSeq Via.

200 OK, SDP. . INVITE- , SIP .

BYE, 200 OK.

-, .

2.8.2.8 SIP

2.19 , . SIP , - ().

SIP 1. 1 SIP- IP- (RTT), .

2.6 SIP- .

2.6 – SIP-:

0	10	Trying . — 10000 .
1	500 ()	RTT ().

2	4	INVITE- INVITE. — 4000 .
4	5	, . — 5000 .
	= 1	INVITE (UDP). — 1000 .
	64*1	INVITE-. — 1000 .
	> 3	proxy INVITE transaction timeout. — 1000 .
D	> 32 UDP 0 TCP/SCTP	.
E	= 1	INVITE- (UDP). — 1000 .
F	64*1	INVITE-. — 1000 .
G	= 1	INVITE. — 1000 .
H	64*1	. — 1000 .
I	4 UDP 0 TCP/SCTP	. — 1000 .
J	64*1 UDP 0 TCP/SCTP	INVITE- . — 1000 .
K	4 UDP 0 TCP/SCTP	. — 1000 .

2.8.2.9

1. SIP
2. Q.931 IP-, .
3. -7 IP-, .
4. SIP U.
5. SIP C.
6. SIP.
7. SIP .
8. SIP .
9. IP- SIP .
10. SIP.

2.9 .

, , .

.

, G.711 (1965), , .
 , , (, PLMN, VoIP) ITU-T ETSI.

VoIP , ITU-T ETSI, - . .

VoIP, VoIP, VoIP-, . :

- . ;
- , (MOS), 5- .

IP- , IPTD – . 400 (. G.107 Y.1541). IPTD , :

- ;
- /.

2.7.

2.7 –

	G.711 ITU-T 1965 .	G.711 ITU-T 1999 .	G723.1 ITU-T 1995 .	G.728 ITU-T	G.729 ITU-T	GSM-FR ETSI GSM 06.01 1987 .	GSM-HR ETSI 1994 .	AMR
/	64	64 56	1) 6,3 2) 5,3	16	8	13	6,5	4,75 12,2
	125 (0,125) 1	10 80	1) 24 30 2) 20 20	2,5	10 10	20 32	20 16	20 95 244
(MIPS)	0,1 MIPS	0,5 MIPS	16 MIPS	40 MIPS	1) G.729 – 20 MIPS 2) G.729A – 10,5 MIPS	4,5 MIPS	30 MIPS	50 MIPS
(MOS)	4,2 – 4,5 - ISDN	4,2 – 4,45 - ISDN	1) 3,9 2) 3,7	4,0	1) 4,1 2) 3,5	3,7	3,9	4,14

2.10 IP-. QoS

IP- IP-, , IP- .

ITU-T I.350 .430 33, , .

TDM- . 45.196-2001. / :

- 1.
- 2.
- 3.

a.

- i.
- ii. (– ASR)
- iii.

b. (). () :

- i. (. 45.196.2001)
- ii.

IP , (, ,).

IP- TDM- IP- (, , ..).

IP- , TDM-KK .

TDM- – – :

TDM- :

- ;
- ();

- (- BER) (. G.703 1) – .

:

- () ;
- , .

IP , , IP , – , !

IP .

IP- :

- IP- ;
- ;
- , IP- , .

IP- QoS , . QoS (Quality of Service —) – , (SLA).

QoS , « »

, , QoS

- -
- VoIP
- , ,

2.10.1 ,

IP (Connectionless Network Services – CLNS). , IP , :

- ;
- ;
- ;
- .

, , .

IP-, , IPTV , , IP- .

, IP, , .

TCP , .

UDP, , , , TCP, , , IP, .

, , (,), , , .

, (Quality of Service - QoS).

, :

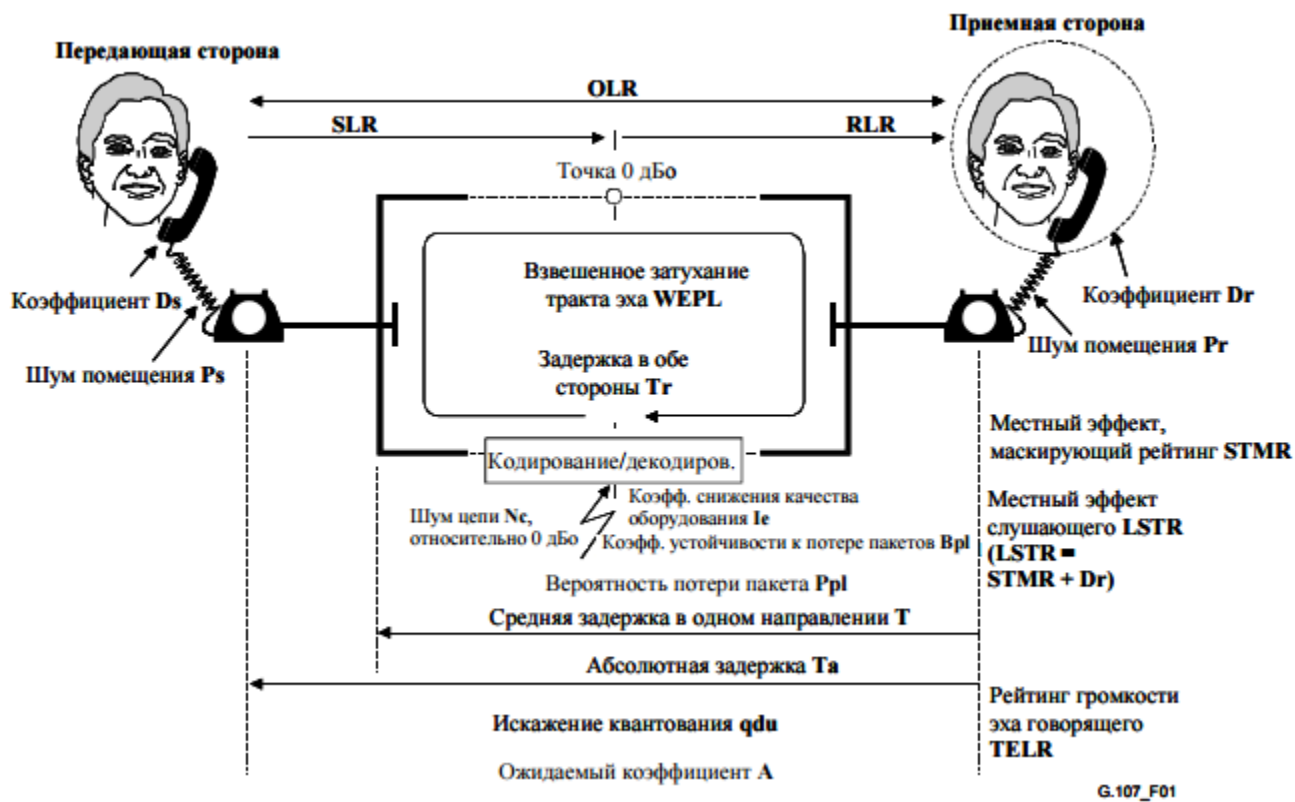
- ;
- ;
- ;
- .

:

1. IP (,) .
2. – .
3. , . !

, IP-, , , .

ITU-T G.107 -, – R-, 20 , (. 2.20):



G.107_F01

2.20 – (G.107 – ITU-T)

20 – (2.8).

2.8 – (. G.107)

Параметр	Аббрев.	Единицы	Значение по умолчанию	Разрешенный диапазон	Замечание
Рейтинг громкости передачи	SLR	дБ	+8	0 ... +18	(Прим. 1)
Рейтинг громкости приема	RLR	дБ	+2	–5 ... +14	(Прим. 1)
Рейтинг маскировки местного эффекта	STMR	дБ	15	10 ... 20	(Прим. 2)
Рейтинг местного эффекта слушающего	LSTR	дБ	18	13 ... 23	(Прим. 2)
Значение D телефона на передающей стороне	Ds	–	3	–3 ... +3	(Прим. 2)
Значение D телефона на приемной стороне	Dr	–	3	–3 ... +3	(Прим. 2)
Рейтинг громкости эха говорящего	TELR	дБ	65	5 ... 65	
Взвешенное затухание канала эха	WEPL	дБ	110	5 ... 110	
Средняя задержка канала эха в одном направлении	T	мс	0	0 ... 500	
Задержка в двух направлениях в 4-проводной замкнутой цепи	Tr	мс	0	0 ... 1000	
Абсолютная задержка в соединениях, свободных от эха	Ta	мс	0	0 ... 500	
Число устройств с искажением квантования	qdu	–	1	1 ... 14	
Коэффициент снижения качества оборудования	Ie	–	0	0 ... 40	
Коэффициент устойчивости к потере пакетов	Bpl	–	1	1 ... 40	(Прим. 3)
Вероятность случайной потери пакетов	Ppl	%	0	0 ... 20	(Прим. 3)
Коэффициент всплеска	BurstR	–	1	1 ... 2	(Прим. 3)
Шум цепи относительно точки 0 дБс	Nc	дБм0п	–70	–80 ... –40	
Пороговый шум на стороне приема	Nfor	дБмп	–64	–	(Прим. 3)
Шум помещения на стороне передачи	Ps	дБ(А)	35	35 ... 85	
Шум помещения на стороне приема	Pr	дБ(А)	35	35 ... 85	
Коэффициент выигрыша	A	–	0	0 ... 20	

2.10.2

ITU-T Y.1540 IP-:

1. – C (I) (Performance).
2. // (Dependability, Reliability).
3. IP-.
 - a. – IPTD.
 - b. – IPDV ().
 - c. / – IPLR / IPER.

, 33 IP- Y.1540 :

2.9 – , IP-

0\	,	0	
0			
	(I)	IPLR,	,
	IPTD (),	IPER	,
	IPDV ()		

, (IP-) IP- TDM-.

TDM- , , , . 45.196-2001 .

, , , , .

IP- , (IPTD, IPDV, IPLR, IPER).

.

1. – C (I) (Performance)

(L1, , E1, STM-1, FE, GE ..) , /. () , (,) , – , (= 1 –)!

(L2) , . / , , (53 = 48 + 5). L2 , ., Ethernet – 46, (1518,) () – . , Ethernet. , , – Ethernet 80 360 , Ethernet, (IPTV) – 1000 ., Ethernet .

(L3) / , () . , –.

(, Softswitch, , ,) (,) . – – /, – busy hour call attempts (BHCA)., () Softswitch 30 . .

2. // (Reliability)

:

- – (Mean time to failure, MTTF) – T.
- MTTF – MTBF (Mean time between failures),) — – T. , Ethernet D-Link = 100 000 600 000 .
- () – Mean time to recovery (MTTR) SDH – < 50 .
- – (). : = / (+)

«».

10-15 «5 », **99.999%** ().

"" :

- 99% 3.7 /
- 99.9% 9 /
- 99.99% 53 /
- 99.999% 5.5 / – SDH!

< 98% (= 7).

IP

3. IP – IPTD (IP packet transfer delay)

IPTD . ITU-T G.114.

2.10 – (G.114)

	QoS G.114		
	"5"	"4"	"2"
IP IPTD (max)	< 150	150...400	> 400

IPTD :

T = + + +

1) – () – (, –).

T – 10 60

2) – , .

T (. G.114) – 1 3 /300

3) T – () – , , . – . () , .

4) – – , , (SLA). – – (**60 % IPTD**). – .

4. IP – IPDV (IP packet delay variation)

() IP.
IP , () () , «» («») « » («»), – .

5. IP – IPLR (IP packet loss ratio)

IPLR .
IP , IPTD, Tmax.

, – ,

6. IP – IPER (IP packet error ratio)

IPER , , .

2.10.2.1 QoS (Y.1541)

ITU-T Y.1541 6 IP- :

- 0 – , , (VoIP).
- 1 – , , (VoIP).
- 2 – , (,).
- 3 – , .
- 4 – , (, ,).
- 5 – IP (BE – Best Effort –).

:

2.11 – Y.1541

	QoS					
	0	1	2	3	4	5
IP, IPTD	100	400	100	400	1	
IP, IPDV	50	50				
IP, IPLR	110 ⁻³	110 ⁻³	110 ⁻⁵	110 ⁻⁵	110 ⁻⁵	
IP, IPER	110 ⁻⁴	110 ⁻⁴	110 ⁻⁵	110 ⁻⁵	110 ⁻⁵	

– .

2.10.3 (MOS, E-)

VoIP : VoIP ,
. VoIP .

ITU-T P.800 MOS (Mean Opinion Score).

MOS , , , («») , , .

5- :

- 5 – ,
- 4 – ,
- 3 – ,
- 2 – ,
- 1 – .

3,5 , 3,0...3,5 - , 2,5...3,0 - .

MOS 3,5 .

MOS , .

MOS .

, :

- (end-to-end) (IPTD);
- (– IPDV);
- (IPLR).

, MOS , .
 , .

ITU-T 1998 . - (. G.107) – ,

- , , .

- , .

- .

- , R- ("Rating Factor").

- R- 0 100, 100 .

R- 20 .

(. . 1 . 2):

- ,
- ,
- - ,
- , (),
- .

R- :

$R = R_o - I_s - I_d - I_e + A,$

:

$R_o = 93,2 - R - (R_o = 15 \cdot 1,5(SLR + N_o));$

I_s - , ;

I_d - ;

I_e - , , ;

A – (SLA, ,).

R- MOS.

R- – , R-.

, (), R- (, R_o) , 93,2, MOS, 4,4.

, - 4,4 MOS .

2.12 – QoS R- MOS

R-		MOS
90<R<100		4,34 – 4,50
80<R<90		4,03 – 4,34
70<R<80	()	3,60 – 4,03
60<R<70	()	3,10 – 3,60
50<R<60	()	2,58 – 3,10

R- 50 .

2.13 – (R- MOS)

	, /	R-	MOS
G.711	64	93,2	4,4
G.729	8	82,2	4,1
G.723.1m	6,3	78,2	3,9
G.723.1a	5,3	74,2	3,7

2.10.4

2.10.4.1 IP- (DiffServ, IntServ)

TDM- ().

, , . , (, ,).

– .

, – IP. IP . , , (, ..). – Best Effort (1981), IP (RFC-791).

IP – .

IP – (CLNS), , , .

, . , exe- 1 , 1- ($= 10^{-6}$) .

IP, – ToS. , () . IP, TCP, (). (IP-) , IP !

, , IP – !

«» , , IP ?

IP:

- DiffServ (ToS, DSCP, COS);
- Int-Serv (RSVP, RAS, LDP,...);
- MPLS, VLAN (802.1p/Q) (Int-Serv DiffServ).

, , N-ISDN, FR, ATM, IP, MPLS .

2.10.4.2 IntServ (Integrated Services)

, , :

- TDM (PSTN, PLMN, N-ISDN);
- ATM (1992...1996);
- RSVP (1994-2000), RFC 1633, RFC 2205, RFC 2705;
- MPLS (1998...2004).

(RFC 1633, 2205, 2705) , :

- ;
- .

RFC 1633 IntServ :

1. (packet scheduler) – .
2. (classifier) – .
3. (admission control) – .
4. (Resource reSerVation Protocol – RSVP).

IntServ .

QoS , .

?

«» QoS, DiffServ.

2.10.4.3 Diff Serv

DiffServ , :

- 1996...98 – . ;
- 1999...2002 – DSCP (DiffServ Code Point) – DS – RFC-2475, PHB – RFC-3140;
- 2000...2004 – DiffServ Traffic Engineering (DS-TE).

Diff-Serv , DS () :

1. (DS);
2. – Core Network (PHB).

, , RFC-2475 :

- 1.
- 2.

DiffServ DSCP, 6 ToS IP- , .

RFC-2475 :

1. .
2. («»).
3. («»), () , , !

0 .

(DS)

.

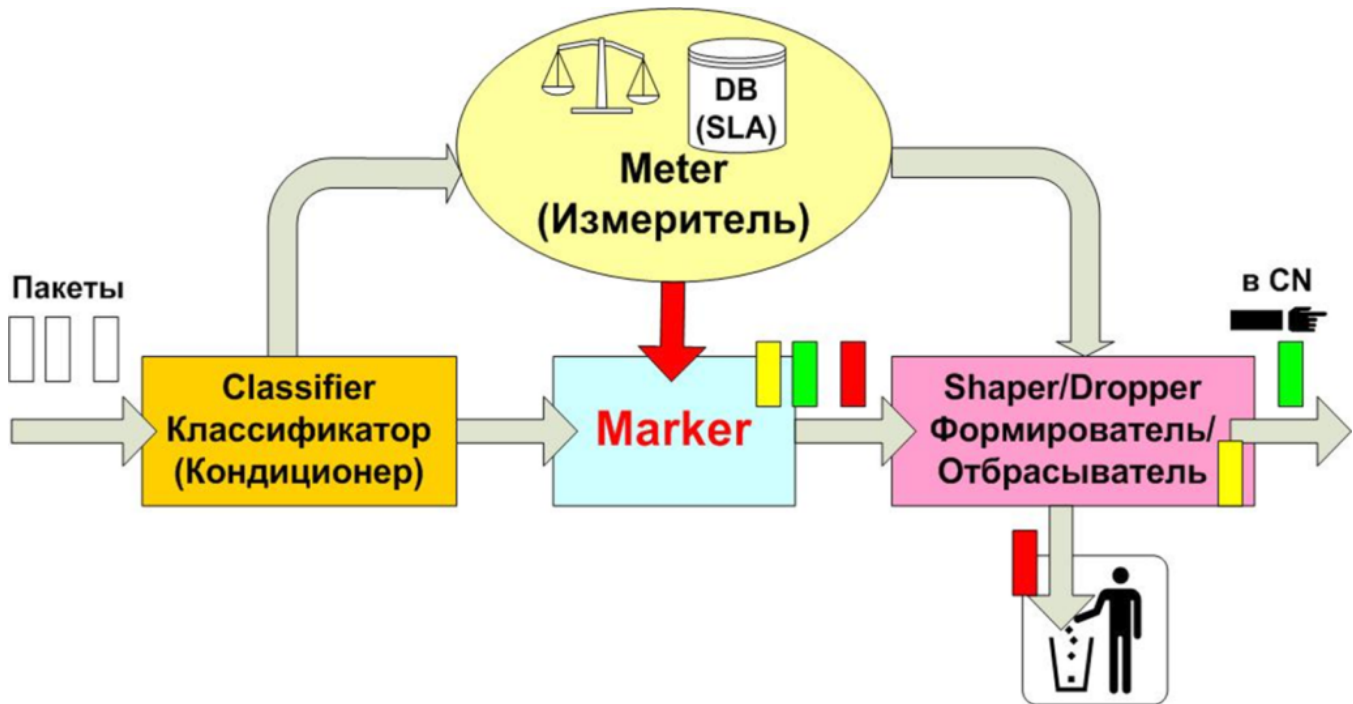
— , , .

:

- , , (ACL);
- (SLA);
- DSCP (DiffServ Code Point) – 6 , 26=64 ;
- (shaping) .

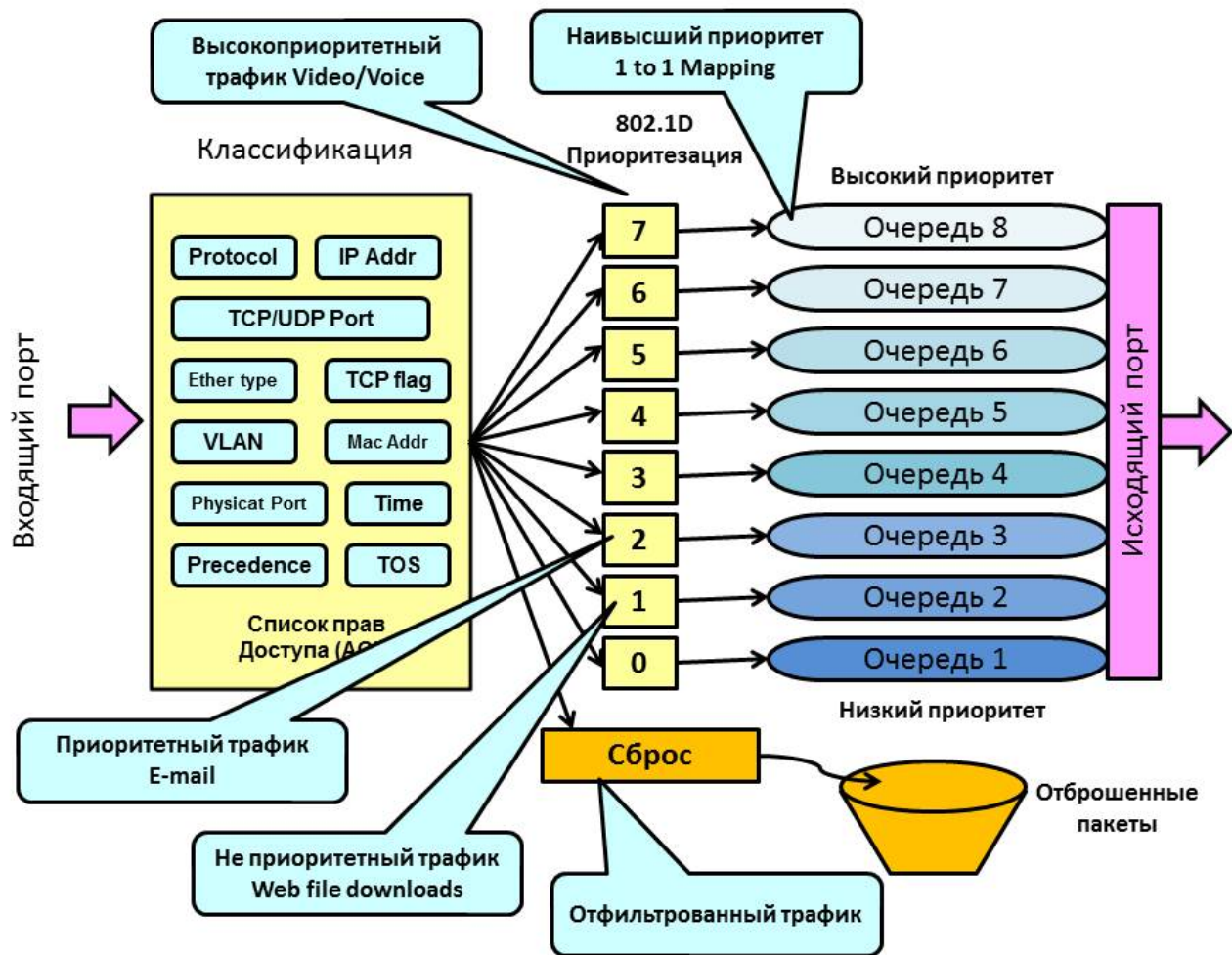
DS (port-access), , :

- ;
- BRAS (Broadband bordur Router Access Server);
- LER / MPLS (Label Edge Router);
- (SBC) .. .



2.21 – DiffServ RFC-2475

2.22 Diff_Services :



2.22 – DiffServ

– SLA.

(Service Level Agreement, SLA) – (SLA – V, V, , T, ...).

(SLA) :

1. 0.
2. .
3. .
4. .
5. .
6. QoS.
7. , , , ..

SLA QoS. SLA , SLA – .

– :

- (, ,),
- ,
- ..

(IP-dest, ToS, TCP-UDP-port, ...).

SLA, DSCP (6).

.. , ..

(Shaper) , (SLA).

:

1. , TDM-.
2. IPTD, IPDV, IPLR, IPER .
3. (MOS) - (- R-).
4. , (Diff_Serv) (Int_Serv).

DiffServ – – **Core Network**.

, – PHB – Per-Hop-Behavior – .

, QoS:

1. – **EF** (Expedited Forwarding) (RFC-3246), (Int_Serv CBR ATM).

.

2. – **AF** (Assured Forwarding) (RFC-2597), 4- , (AF1-AF4) (AF11 AF43):

- ;
- () ;
- .

3. – **Best Effort (BE)**, (QoS).

PHB , L3/L2 (IPP-ToS, DSCP, CoS).

2.14 – PHB IPP, DSCP CoS

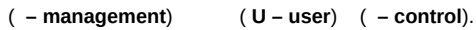
	L3			L2	
	IP-Pr	PHB	DSCP	CoS/MPLS-exp	
	6	CS6	48	6	
(VoIP)	5	EF	46	5	
()	4	AF41	34	4	
(IP-TV,)	4	CS4	32	4	
	3	-	25	3	
	3	AF31/CS3	26/24	3	
(-)	2	AF21	18	2	
(SNMP)	2	CS2	16	2	
(FTP, e-mail, ...)	1	AF11	10	1	
(,)	1	CS1	8	1	
	0	0	0	0	

CS – , Cisco.

, , !

2.10.5

1. QoS.
2. QoS TDM-KK IP-.
3. , IP-.
4. IP-.
5. , IPTD.
6. QoS . Y.1541.
7. Y.1541 0 1.
8. MOS -.
9. -.
10. IP- (DiffServ, IntServ).
11. IntServ.
12. , DiffServ.
13. DiffServ.
14. SLA.
15. () PHB.
16. PHB .



:

- () , ;
- NP QoS () .

() , , , , .

, – .

. ITU-T X.700 M.3010 5 :

1. **FM (fault management)** – ;
2. **CM (configuration management)** – ;
3. **AM (accounting management)** – ();
4. **PM (performance management)** – ;
5. **SM (security management)** – .

FCAPS ().

, , (Systems Management Function, SMF), .

, , .

, , – . , , , , , , , , , , .

, .

(fault management – FM) , , – (alarms). , , . (,), , , .

:

- ;
- ;
- ;
- ();
- ;
- .

– (,) , .

(accounting management – AM) – - .

:

- ;
- ;
- ;
- .

– , , .

(configuration management – CM) (), . - .

:

- ;
- ;
- ;
- ;
- .

: ; ; ; , ; ; ; .

(performance management – PM) , , , , , .

. , , , . – () . , , .

, () . , , .

/ :

- QoS;
- ;
- ;
- .

(security management – SM) :

- (management of security) — ;
- (security of management) — , , .

:

- ;
- ;
- ;
- ;

— , .

, (– OMC), .

(, , – ,), .

2.11.3 «-» SNMP

-, - , - .

(Network Management Systems – NMS) .

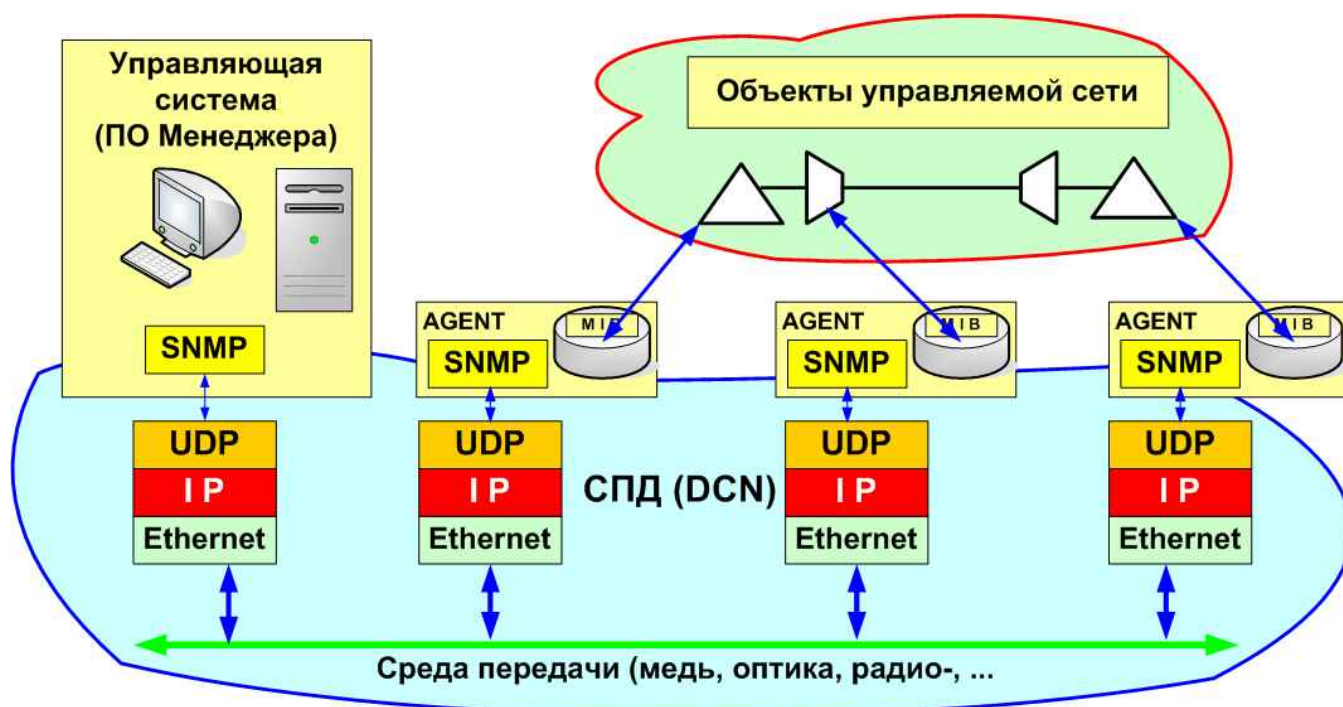
, , – SNMP (Simple Network Management Protocol –).

, , SNMP-. SNMP- - .

, TCP-UDP/IP. Ethernet.

2.24. SNMP , - , , , .

-(. 2.24)



2.24 –

SNMP IETF RFC 1157 () , , , (Management Information Base – MIB), (MIB). SNMP («-» -).

SNMP, , , .

SNMP, , UDP/IP. ATM, Ethernet, PPP .

, , .., 5% .

2.11.3.1

0. , , , , , MIB ().

().

, , , , F, G, (WS).

, - , — , , , SDH, , .. , - .

- :

- ;
- (– alarm);
- , ;
- ;
- ..

, ITU-T X.700 5- :

- – CM (Configuration Management);
- - FM (Faults Management);
- – PM (Performance Management);
- – AM (Account Management, Billing);
- () – SM (Security Management).

.73, .74, .800 .3 .

2.11.4

. SNMP/UDP/IP/Ethernet, .

2.11.5 IETF (TCP-UDP/IP)

2.25 ISO.

OSI-ISO		IETF			
		(HP_OV, TNG, ...)			
	7				SNMP
	6				(161,162)
	5				
	4				TCP, UDP
	3		(WAN)		IP
	2				Ethernet, ATM, FR, LAPD, ...
			(LAN, MAN)		
	1				

2.25 – SNMP/UDP/IP/Ethernet

2.11.6 SNMP

2.11.6.1

SNMP .

SNMP, :

- , SNMP;
- MIB SNMP — ASN.1 (ISO 8824:1987, ITU-T .208);
- MIB (MIB-I, MIB-II, RMON, RMON 2), ISO.

SNMP . SNMP , ADSL, ATM ..

SNMP — TCP/IP. SNMP , , MIB (Management Information Base).

SNMP MIB SNMP, MIB I MIB II. SNMP .

.

, SNMP – MIB.

SNMP — , , , MIB .

, SNMP, , , .

SNMP , .

- MIB (management information base) – , MIB , - (. – – MIB).

, MIB, , . MIB ISO ITU-T (), (private), MIB.

SNMP, , :

- MIB ;
- MIB ;
- ;
- .

2.11.6.2 SNMP

IETF 1990- RFC-1157 .

SNMP , SNMPv1 :

- ;
- ;
- .

SNMPv2 (RFC-1901...1910) SNMPv3 (RFC-3410...3419).

«Simple» (. simple –) .

SNMP (MIB), SNMPv2, SNMPv3.

SNMP, , MIB .

SNMP , , , ..

2.11.6.3 SNMP

(RFC-1157), , , .

, SNMPv1 (,):

- – . — «» — «community string». SNMP «», , community string , , . , ;
- – UDP (SNMP) (trap) , ;
- – SNMP- , - . SNMP- , . . , , .

., HP OpenView Telecom DM TMN, TMN ISO, SNMP, SNMP .

2.11.6.4 () SNMP

SNMP - - , () .

– PDU-SNMP, () .

SNMP- - PDU.

, ("trap" –). (Response) .

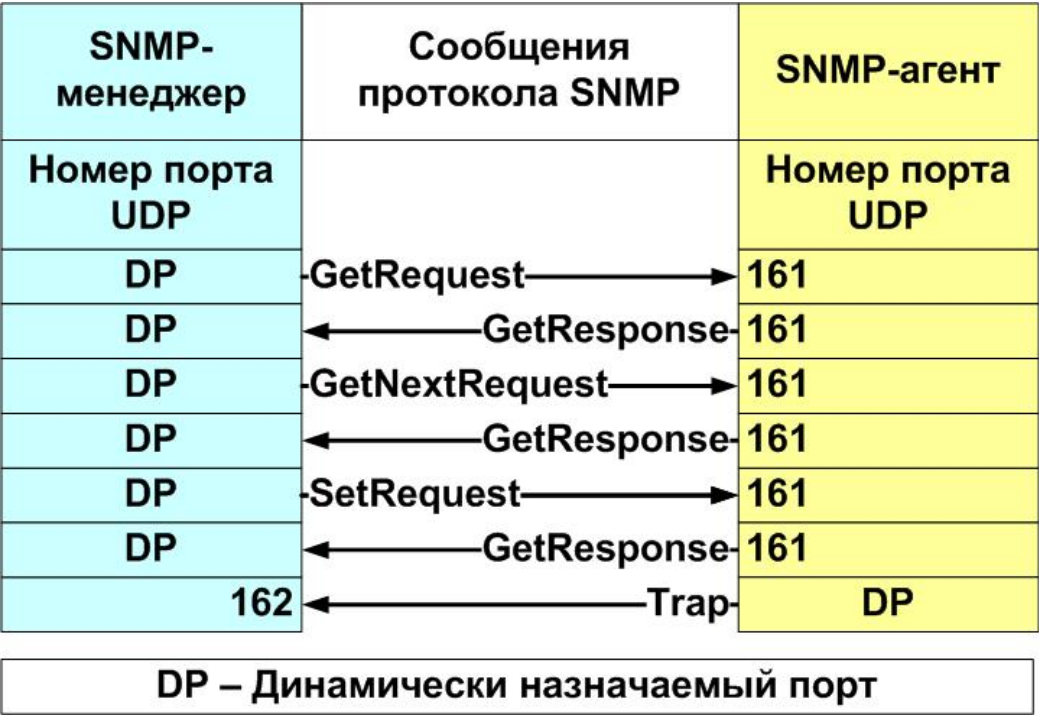
(SNMPv1) – GetRequest, GetNextRequest, SetRequest.

, SNMPv1 5 - (PDU):

- **GetRequest** – PDU . MIB. – **Get**;
- **GetNextRequest** – PDU . MIB, . **GetNext**;
- **SetRequest** – PDU MIB. **Set**. **Set** . , , , , , , , , ;
- **GetResponse** – PDU GetRequest, GetNextRequest, SetRequest. , , **Set**, **Set**. **Reply Response**;
- **Trap** – PDU , (– alarm). – OID, , , , MIB- .

(. 2.26):

- 1. - , ;
- 2. ;
- 3. ;
- 4. , MIB, - .

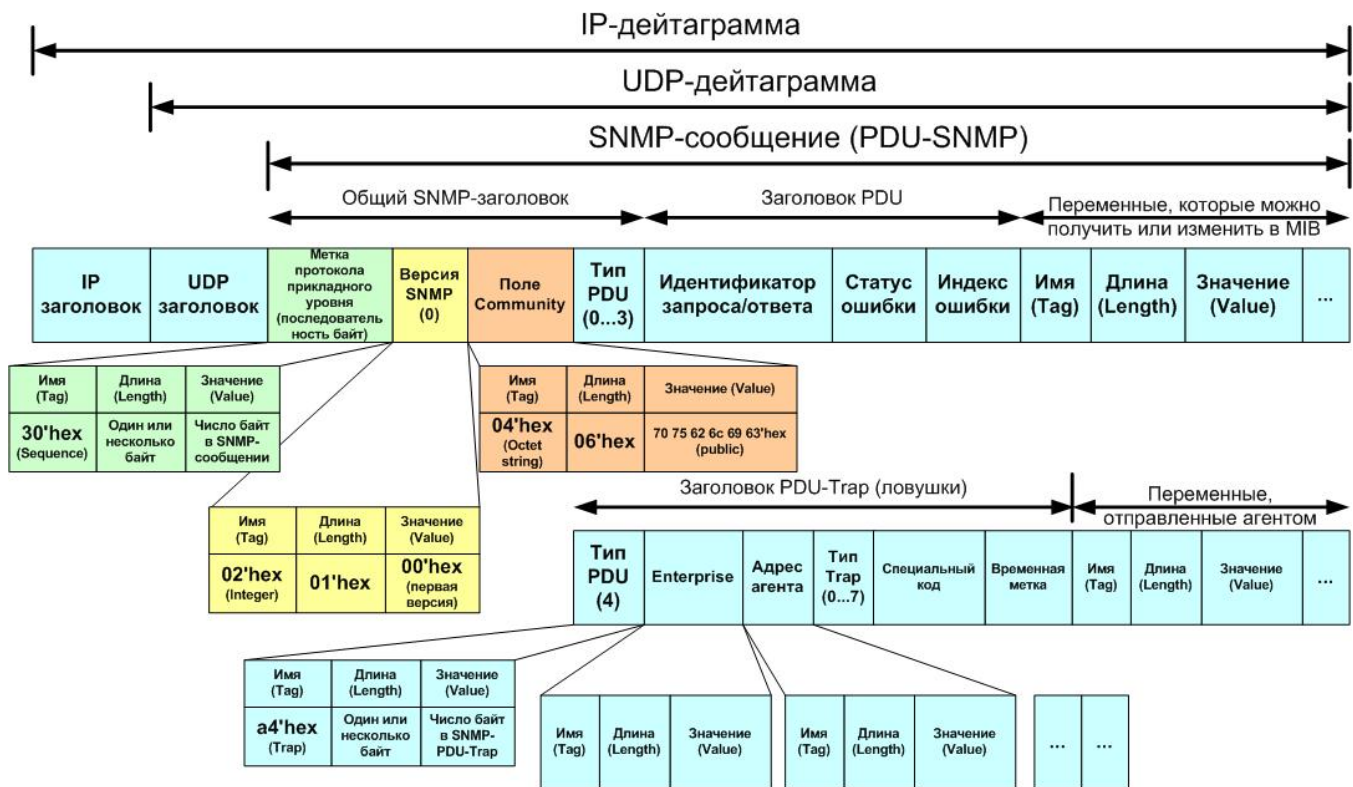


2.26 – SNMP

, GetRequest-PDU, GetNextRequest-PDU, SetRequest-PDU, , GetResponse-PDU Trap-PDU, .
UDP 161. «» (trap) UDP 162. , .

2.11.6.5 SNMP ,

2.27 SNMP- Get, GetNext Set Response.



2.27 – SNMP

SNMP T-L-V (--) BER, ITU-T X.209.

SNMP- :

- . 1 (Version – 1, SNMP).
- . SNMPv1 Community, (). , «public», .
- **PDU (Protocol Data Unit –)**. () ,, (,, ..).

SNMP PDU, PDU Get, GetNext, Set, Response , Trap .

, PDU Get, GetNext, Set, Response:

- **PDU.** , . (). 0 2³²-1. Get, GetNext SET Response, .
- . (), .
- . , (error index) , . error index badvalue, readonly nosuchname.

2.15 –

0	Noerror	;
1	Toobig	;
2	Nosuchname	;
3	badvalue	set ;
4	Readonly	;
5	Generr	.

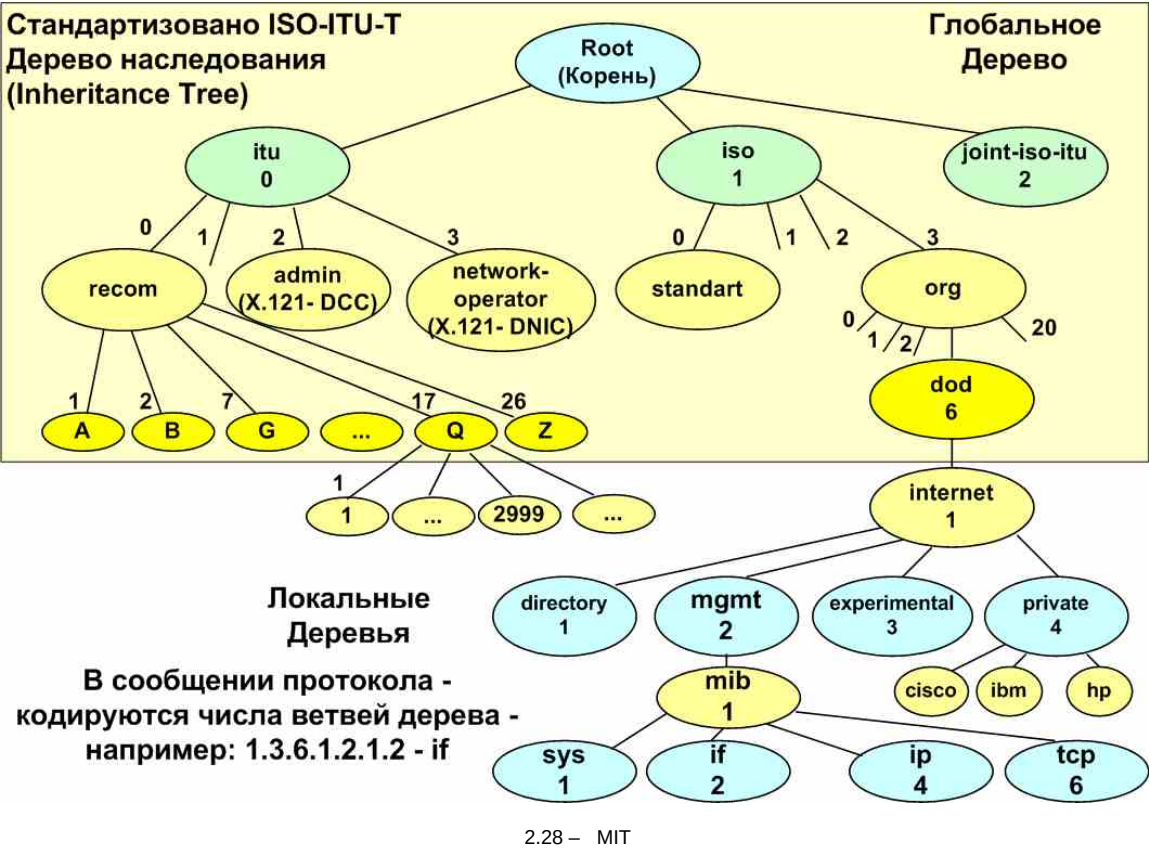
SNMP, , , .

TRAP 0...4 .

() . coldstart 200 .

2.11.7 MIB. , ,

ISO ITU-T , (root) .
ITU-T X.208...X.209 (), 2.28. () .



MIT , – – DNS.
, MIT, .
, – MIB (iso.dod.internet.mgmt, . 2.28), MIT , (MIT):
1.3.6.1.2.1 – MIT.
, (x) 0 (itu-t), 1 (iso) 2 (joint-iso-itu), (y) 40, , MIT, .
, iso.org (x=1.y=3) :
40 + = 40*1 + 3 =43'Dec 2'Hex.
256, , , MIB (iso.org.dod.internet.mgmt.mib, 1.3.6.1.2.1) :

T L V

06 05 2b 06 01 02 01

:

=06 – , , ;

L=05 – (OID);

V=2b 06 01 02 01 – OID (MIB) (, – OID).

2.16 OID .

2.16 – OID

OID

OID

{ 0 0 }	ITU-T
{ 1 0 }	ISO
{ 1 3 6 }	iso.org.dod –
{ 1 3 6 1 }	iso.org.dod.internet –
{ 1 2 840 }	iso.member-body. ANSI (US)
{ 2 5 }	(X.500)
{ 2 5 8 }	-

2.11.7.1 – MIB

, . , – MIB, . , MIB.

MIB, , IETF, .

, MIB, .

.

MIB, . MIB

- MIB I (Internet MIB - RFC 1065, 1066, 1155, 1156, 1157, 1158) – , MIT, - (ARP, IP, TCP, UDP ..). , . , MIB-I. 170 .
- MIB II (RFC-1213 ..).
- RMON-1 MIB (RFC 1757). 10 (.).
- RMON-II MIB (RFC 2819). .

MIB MIT-Internet:

iso.org.dod:

internet OBJECT IDENTIFIER ::= { iso(1) org(3) dod(6) 1 }

Internet:

directory OBJECT IDENTIFIER ::= { internet 1 }

mgmt OBJECT IDENTIFIER ::= { internet 2 }

experimental OBJECT IDENTIFIER ::= { internet 3 }

private OBJECT IDENTIFIER ::= { internet 4 }

mgmt.mib (2.1.) . 0) :

system OBJECT IDENTIFIER ::= { mib-2 1 }

interfaces OBJECT IDENTIFIER ::= { mib-2 2 }

at OBJECT IDENTIFIER ::= { mib-2 3 }

ip OBJECT IDENTIFIER ::= { mib-2 4 }

icmp OBJECT IDENTIFIER ::= { mib-2 5 }

tcp OBJECT IDENTIFIER ::= { mib-2 6 }

udp OBJECT IDENTIFIER ::= { mib-2 7 }

egp OBJECT IDENTIFIER ::= { mib-2 8 }

transmission OBJECT IDENTIFIER ::= { mib-2 10 }

snmp OBJECT IDENTIFIER ::= { mib-2 11 }

MIB-II:

- **System** – MIB II , (, ..).
- **Interfaces** – 23, (, MTU, , ..).
- **AT (3)** – (Address Translation). MIB-I. . AT ARP (MAC) IP- .
- **IP (42)** – IP- (, ,).
- **ICMP (26)** – (/ , ..).
- **TCP (19)** – , (, , , ..).

- **UDP (6)** – , UDP- (/ , ,).
- **EGP (20)** – Exterior Gateway Protocol (, //).
- **Transmission** – MIB.
- **SNMP (29)** – SNMP: / , , .

MIB , . () (iso.org.dod....) - (1.3.6...).

:

- : system.syscontact.0;
- system.sysUpTime.0;
- (,) : system.sysDescr.0.

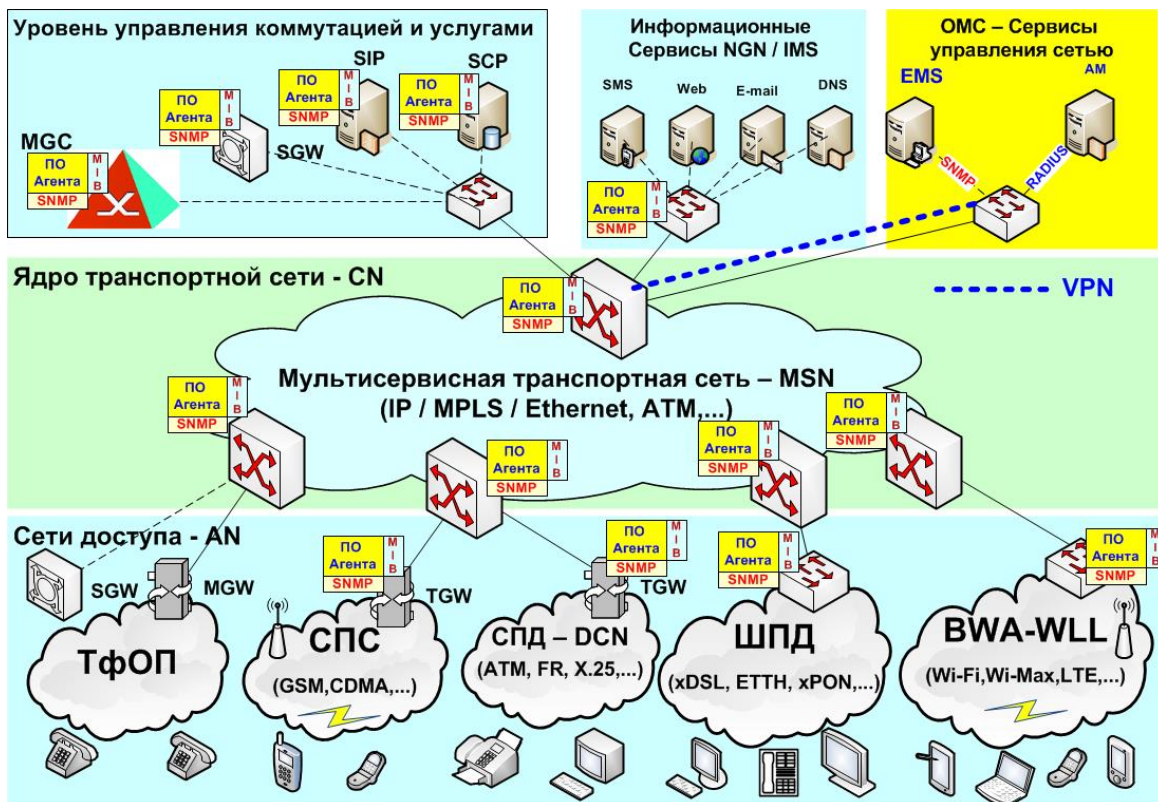
-,

system.sysUpTime.0 1.3.0, system "1" MIB II, sysUpTime – 3 system.

(, ,).

RMON-1 MIB (RFC 1757) : ethernet statistics, history control, ethernet history, alarm, host, hostTopN, matrix filter, packet capture, event.

(, EMS) , , :



2.29 –

2.11.8 MIB

(Vendor) .

, Vendor (MIT).

, (eltexltd) IETF 35625 iso.org.dod.internet.private.enterprises.eltexltd 1.3.6.1.4.1.35625.

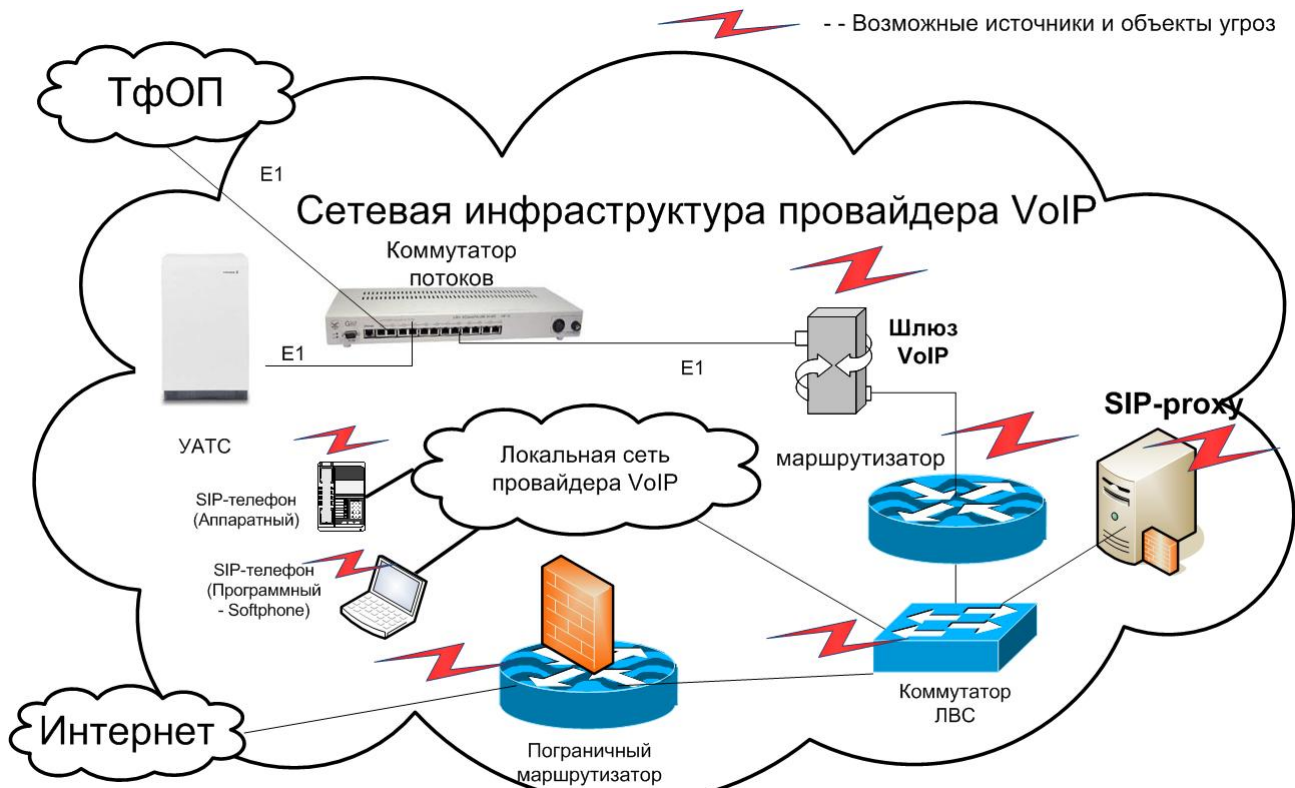
MIB , , . MIB <http://eltex.nsk.ru/> , , TAU-36.IP - <http://eltex.nsk.ru/upload/iblock/b7a/mib.zip>.

2.12 VoIP

IP- « », . VoIP (– « ») , , , .

VoIP 0 .

2.30:



2.30 –

- () , , IP. , IP. – DDoS, «» , , VoIP- (SIP-, IP-, SIP-). (), , , SBC;
- – VLAN (ACL – Access List Classes), ;
- SIP- (, Brio, 3CX ..., ,). VoIP, (SIP-). – SIP- VoIP, VoIP, , IP-, , (PBX), 1-, ;
- VoIP (SIP-proxy, VoIP). SIP- , , , IP. SIP- VoIP, IP-, . (5060, 5061, SIP, Web- SIP-, , – IP,).
- SIP-, ;
- , IP- (VoIP) , IP.

2.12.1.1 VoIP

, , (, VoIP) :

- ;
- ;
- ;
- ;
- ;
- ;
- ;
- ;

, , , VoIP .

, , , VoIP .

- ;
- ;
- ;
- ;
- ;
- ;
- ;
- ;

, , , VoIP .

- «» / () ;
- SIP- , , (-).

2.12.1.2

VoIP :

- IP-, -, VoIP, (80, 445, 1433, 771 .) VoIP / SIP- Web- VoIP;
- , SIP (, SIP- VoIP), - , SIP- (,);
- , , SIP-, . , VoIP, , SIP-, (, VoIP);
- , , (, , .-);
- SIP --, , ;
- VoIP, VoIP (VoIP, ,), , ;
- - - VoIP SIP.

SIP-Proxy (SIP-,), , , .

, , . SIP-. SIP- , , .

, (VoIP). .

C&C-, , - (). , - McAfee -10 C&C - [2].

C&C - (631). - - 237 C&C . -154. -125 C&C , - 95 C&C , - 81 C&C - 77 C&C .

- , , / .

IP-, , - , .

2.12.1.3

VoIP, . VoIP .

ACL- VoIP :

- ACL L2/L3/L4, , - SIP.
- IP-, VoIP, VoIP.

, , , DPI.

, DPI, SIP-, . .

, 2-3 , , , - -. IP-, , IP-, , ACL.

VoIP , , SBC-.

, , VoIP , , .

192	168	5	143
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	1 0 0 0 1 1 1 1
255	255	255	128
1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	1 0 0 0 0 0 0 0
192	168	5	128
1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 1 0 1	1 0 0 0 0 0 0 0