Technical Handbook
(Translated Document)

Carrier Ethernet Service

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Contract	Contract for Data Services Contract for Mitleitungen FMG

Contents

1 Introduction

1. This technical manual describes the technical details for the planning and realisation of the telecommunications service provider (telco) in connection with the Carrier Ethernet Service and Carrier Ethernet Service TCA (hereinafter referred to as CES).

1.1 Referenced documents

[1] EN 300 386: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Telecommunication network equipment; Electromagnetic Compatibility (EMC) requirements"

[2] EN 302 099: "Environmental Engineering (EE); Powering of equipment in access network"

[3] IEEE Standard 802.3 (2002 Edition), IEEE Standard for information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements— Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications, SECTION THREE: This section includes Clauses 34 through 43 and Annexes 36A through 43C.

[4] IEEE Standard 802.1Q (1998), IEEE Standard for information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specification— Virtual Bridged Local Area Networks.

1.2 Definitions

1. High-end access (HE-Access) is the physical optical fibre connection between the customer site and Swisscom Metro Access Element (MAE). The maximum bandwidth is 10 Gbit/s.
2. Low-end access (LE-Access) is the physical connection between the customer site and Swisscom Access Node (CAN/FAN). The maximum bandwidth ranges between 20 Mbit/s and 1000 Mbit/s, dependent on the access technology (e.g. VDSL or FTTH), the distance, and availability.
3. **CES Access**

   CES Access is defined by the following ID: *COL:ACC:xxxxxxxxx*, this always represents the physical basis for the provision of a Carrier Ethernet Service to a PTS site.

   CES Connectivity

   CES Connectivity is defined by the following ID: *CES:CON:xxxxxxxxx*, this is the logical component and defines the bandwidth, the class of service, service level agreement, etc

   CES Service

   CES Service is defined by the following ID: *CES:SRV:xxxxxxxx*, this is the end-to-end connection between two or more CES Connectivity points. Different CES Connectivity points can only communicate with one another if they have been assigned the same CES Service ID.

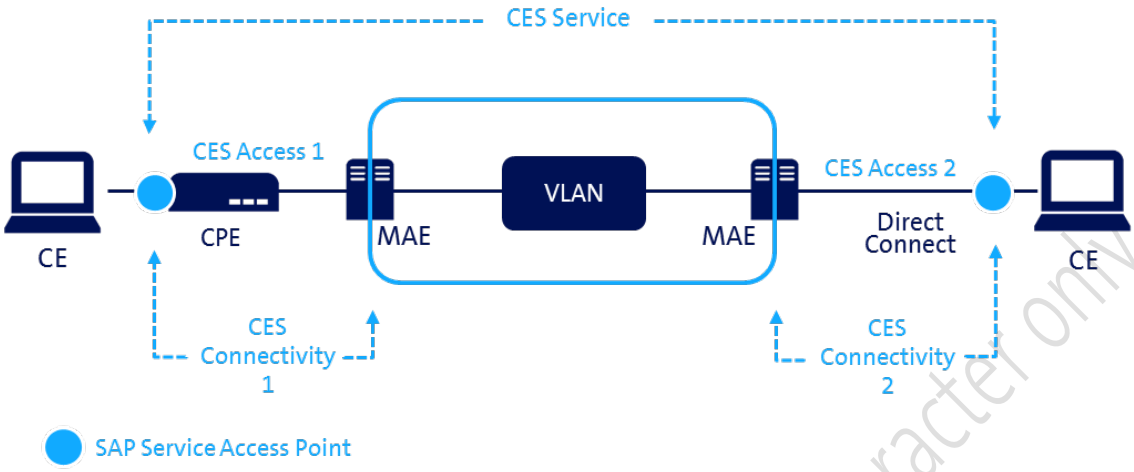

Figure 1: Service overview

2 Technical Service Attributes

2.1 Implementation and architecture

1. CES is based on Ethernet over MPLS-VPLS, supporting point-to-point, any-to-any and rooted multipoint topologies.
2. CES network architecture relies on the highly reliable Swisscom Network, where each Metro Access Element (MAE) is completely redundant.

2.2 Service handover

1. Handover of the CES service to the end customer at the service access Point (SAP), either directly via optical fibre (Direct Connect) or with Customer Premises Equipment (CPE).
2. The CPE is connected via an optical line to the local exchange of Swisscom (PoP). If the handover takes place in multiple exchanges, these are connected via the highly redundant backbone (Swisscom network).
3. The technical solutions displayed in the illustrations are not exhaustive.

2.2.1 Handover of the service outside of a Swisscom local exchange

1. If the service is handed over outside of the Swisscom exchange, this will take place at a customer site or the Point-of-Presence (PoP) of the PTS.
2. The PTS is responsible for the electrical power supply (incl. installation) and the provision of an appropriate rack (19 inch or table version) for the CPE.
3. The installation within the building between the CPE and the equipment of the PTS or the customer equipment (CE) are the responsibility of the PTS and must be made available by it.
4. Swisscom does not provide any remote power supplies.

2.2.2 Handover of the service within a Swisscom local exchange

1. The handover takes place at the customer interface in a room rented by the PTS or its end customers within the local exchange.
2. The PTS is responsible for the electrical power supply (incl. installation) and the provision of an appropriate rack (19 inch or table version) for the CPE.
3. For the realisation of the CES service within the local exchange, Swisscom will install cabling[1] for the PTS between the Swisscom distributor and the rented room of the PTS or its end customer. Details can be found in the area agreement.

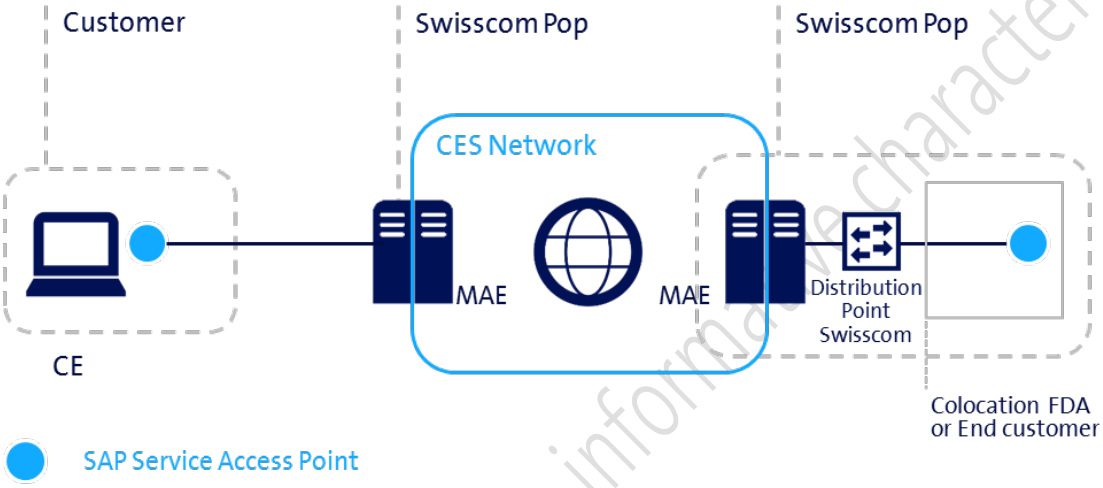

Figure 2: Handover variations

2.3 Service type and port type

2.3.1 EPL/EP-LAN/EP-Tree service types with "Tunnel – Tunnel" configuration

Service type	Description	Port type
EPL, EP-LAN, EP-Tree[2]	With tunnel – tunnel configuration consists on port-based services and uses dedicated physical ports on the SAPs. All SAPs must be configured with the port type Tunnel. Only one port-based service type can be configured to each Tunnel port type.	«Tunnel – Tunnel»

[1] Cabling within the local exchanges are not covered by this service.
[2] For EP-Tree, the Tunnel root port can only be configured over a 10 Gbit/s Ethernet interface with a managed Swisscom High-End CPE (H-CPE).

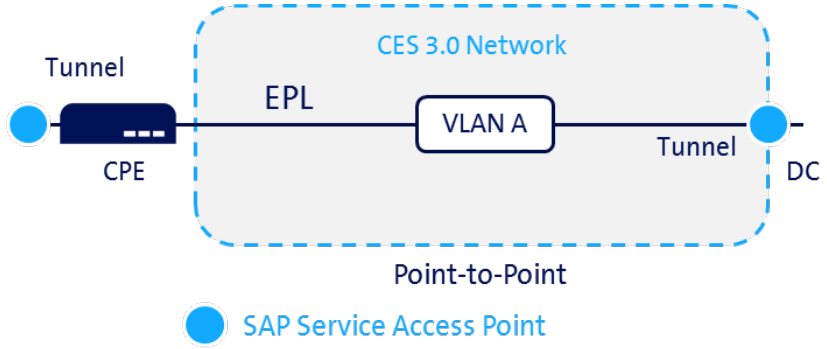

Figure 3: EPL with "Tunnel – Tunnel" configuration

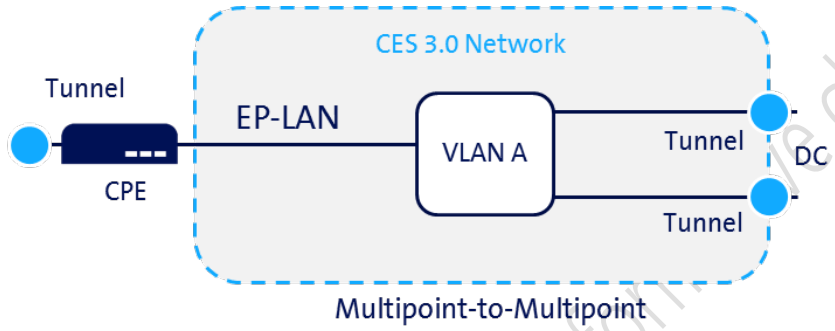

Figure 4: EP-LAN with "Tunnel – Tunnel" configuration

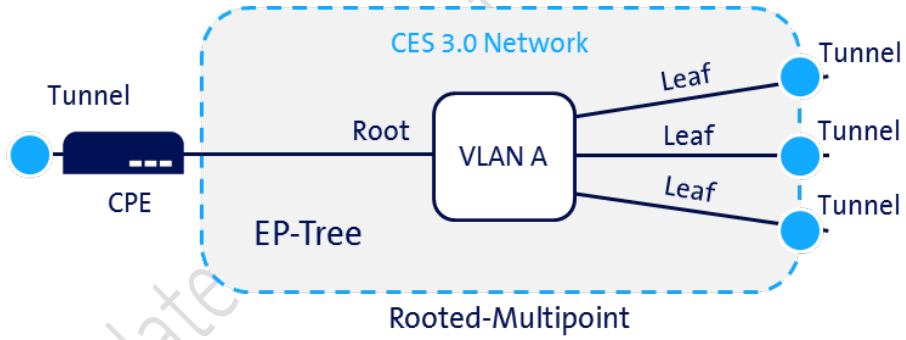

Figure 5: EP-Tree with "Tunnel – Tunnel" configuration

2.3.2 Access-EPL/Access-EP-LAN service types with "Tunnel – ENNI" configuration

Service type	Description	Port type
Access-EPL, Access-EP-LAN	This service configuration allows efficient aggregation of tunneling services at multiple access locations. The aggregation port must be configured with the port type ENNI. An ENNI uses an S-tag which may be additional to the C-tag,	«Tunnel – ENNI»

Service type	Description	Port type
	both assigned by the PTS each S-tag denotes the access location of each tunneling service (e.g. EPL or EP-LAN). ENNI port type is available with Direct Connect or with Swisscom managed High-End CPE (H-CPE), refer to section 2.10.	

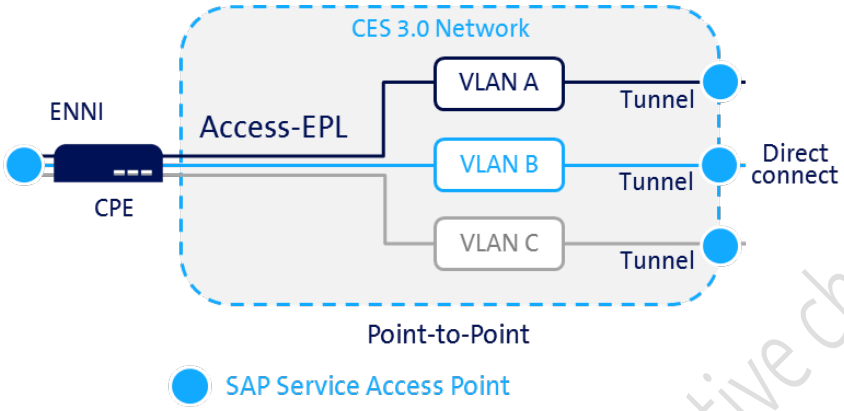

Figure 6: Access-EPL with "Tunnel – ENNI" configuration

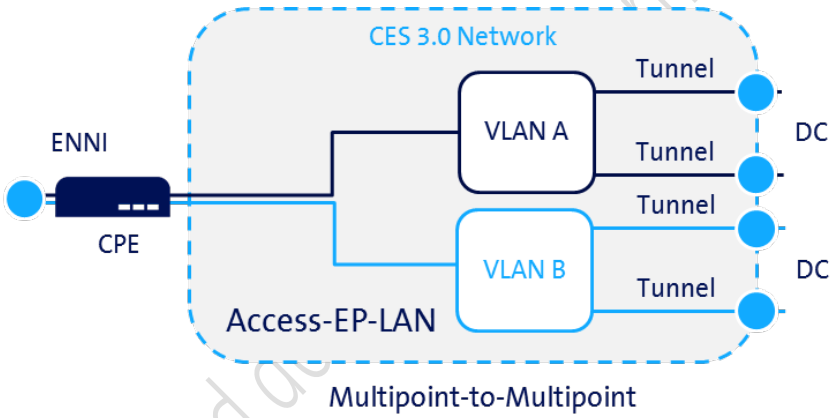

Figure 7: Access-EP-LAN with "Tunnel – ENNI" configuration

2.3.3 EVPL/EVP-LAN/EVP-Tree service types

Service type	Description	Port type
EVPL, **EVP-LAN,** **EVP-Tree**[3]	This configuration enables multiple VLAN-aware service types to be terminated on one SAP (i.e. on a CES Access port). This variant uses VLAN IDs (C-tags), assigned by the PTS, for each service type.	«Trunking» (recommended)

[3] For EVP-Tree, the Trunking/Untagged root port can only be configured over a 10 Gigabit Ethernet interface with a managed Swisscom High-End CPE (H-CPE).

Service type	Description	Port type
	This configuration makes it possible to send and receive untagged Ethernet frames on the SAP. The Ethernet frames should not have a C-tag in the Ethernet header.	«Untagged» (no trunking)

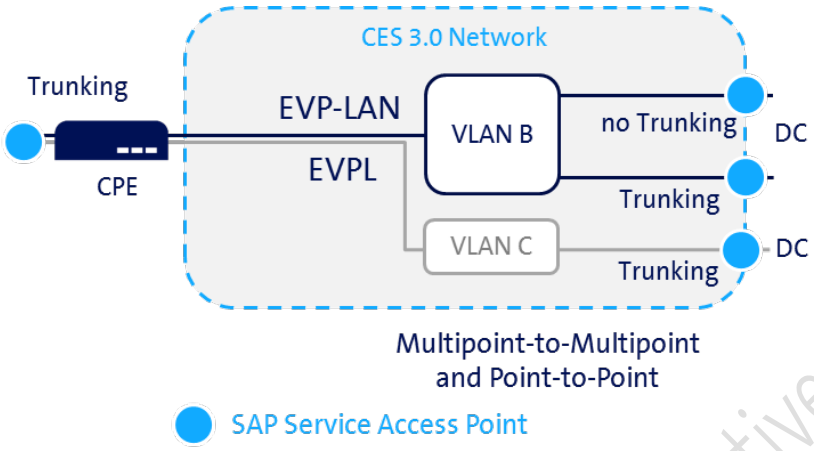

Figure 8: EVPL/EVP-LAN with / without trunking

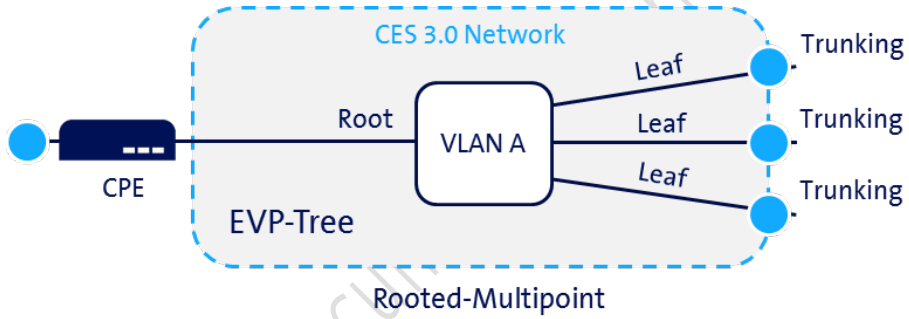

Figure 9: EVP-Tree with / without trunking

2.3.4 EVPL/EVP-LAN/EVP-Tree service transmission

1. **Ethernet frame transparency**

CES EVPL/EVP-LAN/EVP-Tree are suitable for the PTS that connect a layer 3 terminal to the SAP. CES treats layer 2 control protocols in accordance with Table 1 below.

Protocol	Description	Action
CDP/VTP	Cisco Discovery Protocol, Virtual Trunking Protocol, with destination MAC address 0100.0ccc.cccc	reject
UDLD/DTP/	All other protocols with destination MAC	reject

Protocol	Description	Action
Pagp, etc.	address 0100.0ccc.cccc	
SSTP	Shared Spanning Tree Protocol, Destination MAC address 0100.0ccc.cccd	reject
STP/MSTP/ RSTP	Spanning Tree Protocol family with destination MAC addresses 0180.c200.0000 to 0180.c200.000f	reject
802.3x Pause (Flow control), 802.3ad LACP, Dot1x, All Bridges Protocol, etc.	All other protocols with destination MAC addresses 0180.c200.0000 to 0180.c200.000f	reject
GARP, etc.	Block of protocols with destination MAC addresses 0180.c200.0020 to 0180.c200.002f	reject
CGMP, etc.	Protocols with destination MAC address 0100.0cdd.dddd	reject

Table 1: EVPL/EVP-LAN/EVP-Tree Ethernet frame transparency

2. We recommend that the PTS only connect layer 3 terminals (routers) to the SAP. If the PTS connects a layer 2 switch, care must be taken at the SAP to ensure all layer 2 control protocols are deactivated. If the PTS nevertheless sends such a control protocol, Swisscom can deactivate the SAPs without prior notification.
3. **Port type**
   For Untagged port types, no CoS .1p bit is available. Hence, traffic is treated as Best Effort for all untagged SAP ports.
   For Trunking port types, Swisscom configures IEEE 802.1Q encapsulation (dot1Q) for all trunking SAP ports.
4. **VLAN ID handling**
   - VLAN ID assignment: The PTS assigns the VLAN ID (C-tag) per CES Connectivity. Per CES Connectivity can be assigned only one VLAN ID (allocation of VLAN ID range is not possible).
   - VLAN ID area: The PTS can use the entire VLAN ID range [2-4096][4] for its CES Connectivity.
   - VLAN ID maintenance: the VLAN ID at the ingress point can differ from the VLAN ID at the egress point.

[4] The following VLAN IDs are excluded from the PTS (network relevant): 1, 1002-1005, 4021-4022.

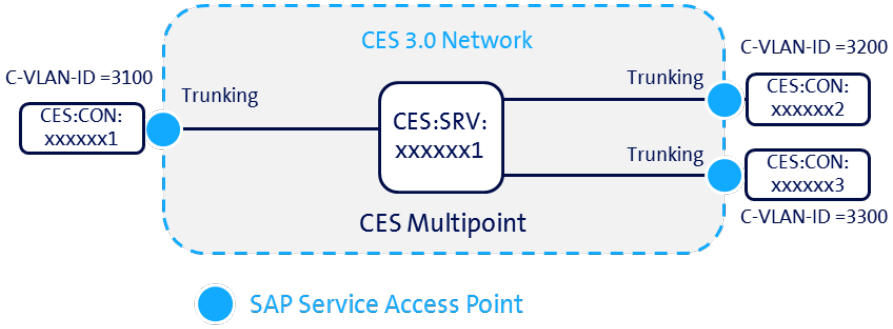

Figure 10: VLAN ID maintenance EVPx

2.3.5 EPL/EP-LAN/EP-Tree/Access-EPL/Access-EP-LAN service transmission

1. **Ethernet frame transparency**
   For EPL/EP-LAN/EP-Tree/Access-EPL/Access-EP-LAN is the MEF transparency standard EPL option 1 supported. This MEF transparency option is particularly suitable for PTS that needs a transparent layer 2 service. The following Layer 2 Control Protocols (L2CP) are tunnelled:

Protocol	Description	Action
CDP/VTP	Cisco Discovery Protocol, Virtual Trunking Protocol, with destination MAC address 0100.0ccc.cccc	tunnel*
UDLD/DTP/ Pagp, etc.	All other protocols with destination MAC address 0100.0ccc.cccc	reject
SSTP	Shared Spanning Tree Protocol, Destination MAC address 0100.0ccc.cccd	tunnel*
STP/MSTP/ RSTP	Spanning Tree Protocol family with destination MAC addresses 0180.c200.0000 to 0180.c200.000f	tunnel*
802.3x Pause (Flow control), 802.3ad LACP, Dot1x, All Bridges Protocol, etc.	All other protocols with destination MAC addresses 0180.c200.0000 to 0180.c200.000f	reject
01-80-C2-00-00-0B	Reserved for future standardization	tunnel*
01-80-C2-00-00-0C	Reserved for future standardization	tunnel*
01-80-C2-00-00-0D	Provider Bridge for MVRP	tunnel*
01-80-C2-00-00-0F	Reserved for future standardization	tunnel*
GARP, etc.	Block of protocols with destination MAC addresses 0180.c200.0020 to 0180.c200.002f	tunnel*
CGMP, etc.	Protocols with destination MAC address 0100.0cdd.dddd	reject

Protocol	Description	Action
L2TP	Layer 2 Tunnelling Protocol, destination MAC address 0100.0ccd.cdd0	reject

Table 2: EPL/EP-LAN/EP-Tree/Access-EPL/Access-EP-LAN Ethernet frame transparency

2. (*) For ENNI egress port, a provider VLAN (S-tag) is added in after the MAC source address and destination MAC address for Cisco proprietary protocols (CDP/VTP) are modified to 01-00-0c-cd-cd-d0. For LE access type, only CDP/VTP/STP/MSTP/RSTP protocols are tunneled.
3. **Port type**
   For Direct Connect, only QinQ tagged frames allowed for ENNI port types. Both 802.1ad and QinQ tagged frames allowed with Swisscom managed High-End CPE. Services with 802.1ad and QinQ tagged frames cannot be mixed on the same ENNI port.
   For LE access types, root tunnelling and ENNI port types are not allowed.
4. **VLAN ID handling**
   - VLAN ID assignment: The PTS can assign individual customer VLAN IDs (C-tags) to each CES Connectivity. For ENNI ports, the PTS assigns the provider VLAN IDs (S-Tags).
   - VLAN ID area: The PTS can use the entire customer/provider VLAN ID range [2-4094][5] for its CES Connectivity.
   - VLAN ID maintenance: the C-tags at the tunnel ingress port are identical to the C-tags at the tunnel egress port. At the ENNI port, the S-tags are also preserved (see Figure 11)
   - For ENNI ports: CES supports a maximum of 1,000 S-Tags per port. The PTS can use either 802.1ad or Stacked C-tags (QinQ) tagged frames.
   - For tunnel ports: There are no limitations with regards to the number of customer VLAN IDs. The PTS can use either dot1Q tagged or untagged frames.

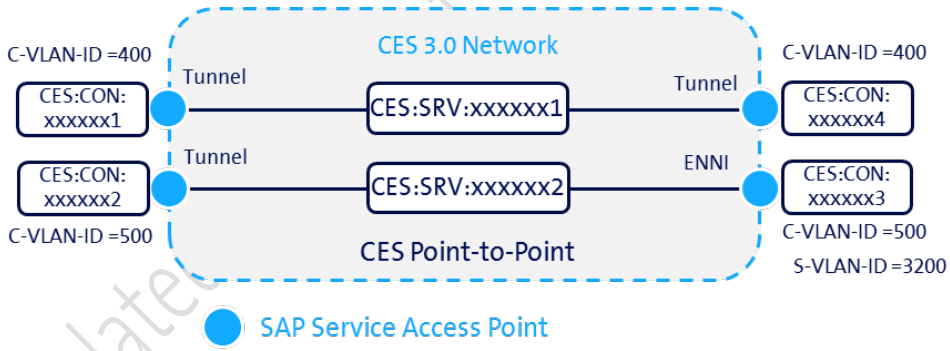

Figure 11: VLAN ID maintenance with EPx

[5] The following VLAN IDs are excluded from the PTS (network relevant): 1, 10, 1002-1005, 4021-4022.

2.4 Further important transmission properties

1. Broadcast, Unknown Unicast and Multicast (BUM) traffic is replicated in Swisscom CES network (WARP). The delivery of Multicast frames is unconditional to all CES Access sites part of the same CES Service. Broadcast and Unknown Unicast frames are conditionally delivered with up to 10'000 pps (packets-per-second) each and to all CES Access sites part of the same CES Service. The exceeded Broadcast and Unknown Unicast traffic will be dropped[6].
2. If the maximum number of MAC addresses per CES Service (default: 4'000 / optional: 10'000) is reached, then new MAC addresses (Unicast, Multicast and/or Broadcast frames) are replicated (flooded) to all ports.
3. CES learns the MAC address of the source MAC from the Ethernet frame. By default, 4'000 MAC addresses are accepted per CES Service. Each Ethernet frame with an additional MAC address is flooded. A block of 6'000 additional MAC addresses is optionally available (total 10'000 MAC addresses). For LE access types, the maximum number of MAC addresses (for upstream traffic) per CES Connectivity is limited to 50.
4. CES supports the Ethernet MTU frame size in accordance with the definition in IEEE 802.1Q and 802.3 Standards. The minimum Ethernet frame size is 64 bytes for all SAP types; the maximum Ethernet frame size is 9000 bytes for 1000BASE-T/1000BASE-SX/1000BASE-LX/LH-/1000BASE-BX10/1000BASE-ZX/10GBASE-SR/10GBASE-LR/10GBASE-ER SAP interfaces, and 1568 bytes for 100BASE-TX SAP interfaces. For LE access, the MTU size is 1794 bytes at the SAP interface.

2.5 Class of service (CoS)

1. CES offers seven traffic classes (Class of Service, CoS): Best Effort, General, Priority, High Priority, Critical Real-Time and Control. Each CoS of the customer is transparently transported through the Swisscom network and it is used to enforce the Committed Access Rate (CAR). The traffic class tag should be provided by the CoS field (CoS .1p bit) in the Ethernet frame of the customer. CES preserves the CoS .1p bit and the frames are transmitted in accordance with the CoS field of the C-Tag or S-Tag.
2. Per CPE are max. 300 CES Connectivity with COS7 supported.

2.5.1 Traffic classification

1. A PTS must classify the Ethernet traffic in accordance with the following specifications:
   All customer traffic (e.g. Ethernet, dot1Q, QinQ, 802.1ad, MPLS, IPv4, IPv6) is classified based on the Priority Code Point (CoS .1p bit) within the Ethernet header. Following Table 3 shows an overview of the traffic classification.

[6] In old Swisscom CES network (EAP), only Broadcast is conditionally delivered. Multicast and Unknown Unicast are delivered unconditionally. For an optical access with 1 Gbit/s physical port, broadcast frames are limited to 30 Mbit/s. The exceeded Broadcast traffic will be dropped.

Verkehrsklasse	Verkehrsklassifizierung		
	Ethernet CoS .1p-Bit	Priorität der Klasse	Gewichtung (garantiertes Minimum)
Control	[6, 7]	Kontrolle und Routing durch den Kunden	5%
Real-Time	[5]	Höchste Weiterleitungspriorität	50% strikte Priorität
Critical	[4]	Zweithöchste Weiterleitungspriorität	40%
High Priority	[3]	Dritthöchste Weiterleitungspriorität	30%
Priority	[2]	Vierthöchste Weiterleitungspriorität	15%
General	[0]	Fünfthöchste Weiterleitungspriorität	9%
Best Effort	[1]	Niedrigste Weiterleitungspriorität	1%

Tabelle 3: Traffic classification

1. If, for example, a CES with Committed Access Rate (CAR) of 100 Mbit/s transmits 50 Mbit/s of Real-Time traffic, the minimum guaranteed traffic for the remaining bandwidth (50 Mbit/s) is distributed as follows: 0.5 Mbit/s for Best Effort, 4.5 Mbit/s for General, 7.5 Mbit/s for Priority, 15 Mbit/s for High Priority, 20 Mbit/s for Critical and 2.5 Mbit/s for Control traffic.
2. CES traffic classification is based on a CoS "trust model". It is a native Layer 2 model where the classification and policy enforcement is done based on the CoS .1p bits of the C-tag or S-tag from the Ethernet frame. The CoS is fully transparent and no rewriting of the CoS .1p bit occurs in the Swisscom network. For untagged Ethernet frames, where no CoS .1p bit is available, the traffic is treated as Best Effort within the Swisscom network.

2.5.2 Profile without CoS

1. All PTS traffic is mapped as Best Effort irrespective of its original .1p bit setting and checked in accordance with Table 4.

Committed Access Rate (Mbit/s)	Best Effort CIR (Mbit/s)	General CIR (Mbit/s)	Priority CIR (Mbit/s)	High Priority CIR (Mbit/s)	Critical CIR (Mbit/s)	Real Time CIR (Mbit/s)	Control CIR (Mbit/s)
2	2	--	--	--	--	--	--
4	4	--	--	--	--	--	--
6	6	--	--	--	--	--	--
8	8	--	--	--	--	--	--
10	10	--	--	--	--	--	--
20	20	--	--	--	--	--	--
30	30	--	--	--	--	--	--
50	50	--	--	--	--	--	--
70	70	--	--	--	--	--	--

Committed Access Rate (Mbit/s)	Best Effort CIR (Mbit/s)	General CIR (Mbit/s)	Priority CIR (Mbit/s)	High Priority CIR (Mbit/s)	Critical CIR (Mbit/s)	Real Time CIR (Mbit/s)	Control CIR (Mbit/s)
100	100	--	--	--	--	--	--
200	200	--	--	--	--	--	--
300	300	--	--	--	--	--	--
500	500	--	--	--	--	--	--
700	700	--	--	--	--	--	--
1000	1000	--	--	--	--	--	--
2000	2000	--	--	--	--	--	--
3000	3000	--	--	--	--	--	--
5000	5000	--	--	--	--	--	--
10000	10000	--	--	--	--	--	--

Table 4: EVPL/EVP-LAN/EVP-Tree traffic profiles without CoS support

2. The Best Effort Committed Information Rate (CIR) total corresponds with the Committed Access Rate (CAR) from the bandwidth profile of the CES Connectivity.

2.5.3 Profile with CoS

3. The customer traffic is classified in accordance with Table 3, and controlled in accordance with Table 3, and controlled in accordance with Table 5.

CES Connectivity CAR (Mbit/s)	Best Effort CIR (Mbit/s)	General CIR (Mbit/s)	Priority CIR (Mbit/s)	High Priority CIR (Mbit/s)	Critical CIR (Mbit/s)	Real Time CIR (Mbit/s)	Control CIR (Mbit/s)
2	2	2	2	2	2	1	2
4	4	4	4	4	4	2	4
6	6	6	6	6	6	3	6
8	8	8	8	8	8	4	8
10	10	10	10	10	10	5	10
20	20	20	20	20	20	10	20
30	30	30	30	30	30	15	30
50	50	50	50	50	50	25	50
70	70	70	70	70	70	35	70
100	100	100	100	100	100	50	100
200	200	200	200	200	200	100	200

CES Connectivity CAR (Mbit/s)	Best Effort CIR (Mbit/s)	General CIR (Mbit/s)	Priority CIR (Mbit/s)	High Priority CIR (Mbit/s)	Critical CIR (Mbit/s)	Real Time CIR (Mbit/s)	Control CIR (Mbit/s)
300	300	300	300	300	300	150	300
500	500	500	500	500	500	250	500
700	700	700	700	700	700	350	700
1000	1000	1000	1000	1000	1000	500	1000
2000	2000	2000	2000	2000	2000	1000	2000
3000	3000	3000	3000	3000	3000	1500	3000
5000	5000	5000	5000	5000	5000	2500	5000
10000	10000	10000	10000	10000	10000	5000	10000

Table 5: ELAN / EVPL traffic profiles with CoS support

4. The total value of the Best Effort, General, Priority, High Priority, Critical, Real-Time and Control CIRs cannot be higher than the Committed Access Rate (CAR) from the bandwidth profile of the CES Connectivity.

2.6 Performance target values

1. The performance target values are used to identify the performance of the Swisscom network. The following target values are generally achieved with regard to the performance of each traffic class:

traffic class	Frame Delay Target Value	Frame Delay Variation Target Value	Frame Loss Ratio Target Value
Best Effort	15 ms	3 ms	0.1%
General, Priority, High Priority, Critical, Control	10 ms	2 ms	0.01%
Real Time[7]	5 ms	1 ms	0.01%

Table 6: performance target values per traffic class

2. The PTS must limit its own data traffic at the CES SAP. If the telco operator utilises more bandwidth than the CAR, non-compliant frames will be rejected. Swisscom is not responsible for non-compliant frames. In such a case, the performance target values of the traffic class are not applied.

2.7 Performance reports

1. For **Services with CoS**, performance reports are available on-demand and provide the PTS the ability to monitor the frame loss[8], delay and delay variation (jitter) of Best Effort and Real-Time traffic through the CES network.

3. The PTS must limit its own data traffic at the CES Connectivity. If the PTS utilises more bandwidth than the CAR, non-compliant frames will be rejected. Swisscom is not responsible for non-compliant frames

[7] Bei Kupfer-Access ist der Zielwert für den Frame Delay 15 ms
[8] Not available for Low-End (LE) access type

which may impact the performance values (loss, delay, jitter) of the relevant traffic classes.

2.8 Customer Premises Equipment (CPE) and interfaces for High-End access

1. For High-End (HE) access, the PTS can choose between the following connection type variants:
Direct Connect (DC) or Swisscom Customer Premises Equipment (CPE), the latter including a Low-end CPE (L-CPE), a Mid-range CPE (M-CPE) or a High-End CPE (H-CPE) option.

Connection type	Interface bandwidth	Interface type
Direct Connect (DC)	Gigabit Ethernet	1000Base-SX, 1000Base-LX/LH, 1000Base-ZX, 1000Base-BX10
	10 Gigabit Ethernet	10GBase-SR, 10GBase-LR, 10GBase-ER
L-CPE	Gigabit Ethernet	10/100/1000Base-T, 1000Base-SX, 1000Base-LX/LH or 1000Base-ZX
M-CPE		
H-CPE	10 Gigabit Ethernet	10/100/1000Base-T, 1000Base-SX, 1000Base-LX/LH or 1000Base-ZX 10GBase-SR, 10GBase-LR, 10GBase-ER

Table 7: Overview of CPE and interface type

2. Per CES HE-Access are 1'000 CES Connectivity supported (therefrom max. 300 with CoS option).
3. The PTS must provide the precise interface type when submitting the order.
4. Swisscom CPE types are determined by Swisscom based on the interfaces and service/port types requested by the PTS.
5. The PTS undertakes to leave any CPE at the site at which they were installed. Any moving of CPE to another location shall require the prior written consent of Swisscom. No modifications may be made to the CPE. Repairs, maintenance or any other intervention on the CPE must be performed by an authorized representative of Swisscom. The PTS ensures that only qualified personnel have access to the CPE.
6. **Direct Connect (DC)** (without Swisscom CPE)
The PTS installs its own equipment and is responsible for managing it.
The SAP is located on the patch panel, which terminates the incoming optical fibre connection at the location. In the event of Dual Homing/Dual Homing Light, the handover to the PTS takes place with two SAPs on the patch panel (the plug depends on the patch panel installed at the customer site).
7. **Low-Range CPE (L-CPE)**
The SAP is located on the physical, LAN-side Ethernet interface of the CPE, where the service is made available:

2 x 1 Gigabit Ethernet LAN	10/100/1000Base-T (Cat-5 UTP RJ-45 plug), 1000Base-SX (MMF LC plug), 1000Base-LX/LH (SMF LC plug), 1000Base-ZX (SMF LC plug)
AC Power 230 VAC	single
Uplink (WAN)	1 x 1 Gigabit Ethernet
Assembly	19' rack / frame / wall
Height	1 rack unit

8. **Mid-Range (M-CPE)**

The SAP is located on the physical, LAN-side Ethernet interface of the CPE, where the service is made available:

8 x 1 Gigabit Ethernet LAN	10/100/1000Base-T (Cat-5 UTP RJ-45 plug), 1000Base-SX (MMF LC plug), 1000Base-LX/LH (SMF LC plug), 1000Base-ZX (SMF LC plug)
5 x 1 Gigabit Ethernet LAN	1000Base-SX (MMF LC plug), 1000Base-LX/LH (SMF LC plug), 1000Base-ZX (SMF LC plug)
AC Power 230 VAC	double (redundant)
DC Power 48 VDC	double (redundant) (available optionally)
Uplink (WAN)	1 x 1 Gigabit Ethernet
Assembly	19" rack / frame / wall
Height	1 rack unit

9. **High-Range CPE (H-CPE)**

The SAP is located on the physical LAN-side Ethernet interface of the CPE, where the service is made available:

8 x 1 Gigabit Ethernet LAN	10/100/1000Base-T (Cat-5 UTP RJ-45 plug), 1000Base-SX (MMF LC plug), 1000Base-LX/LH (SMF LC plug), 1000Base-ZX (SMF LC plug)
4 x 1 Gigabit Ethernet LAN	1000Base-SX (MMF LC plug), 1000Base-LX/LH (SMF LC plug), 1000Base-ZX (SMF LC plug)
1 x 10 Gigabit Ethernet LAN	10GBase-SR (MMF LC plug), 10GBase-LR (SMF LC plug), 10GBase-ER (SMF LC plug)
AC Power 230 VAC	double (redundant)
DC Power 48 VDC	double (redundant) (available optionally)
Uplink (WAN)	1 x 10 Gigabit Ethernet
Assembly	19" rack / frame / wall
High	1 rack unit

2.9 Customer Premises Equipment (CPE) and interfaces for Low-End access

1. Low-End access is the access type based on existing Swisscom VDSL or FTTH infrastructure delivered over copper (Low-End Copper, LEC) or fiber (Low-End Fiber, LEF), respectively. Note that FTTH/LEF access type will be available in a future release.

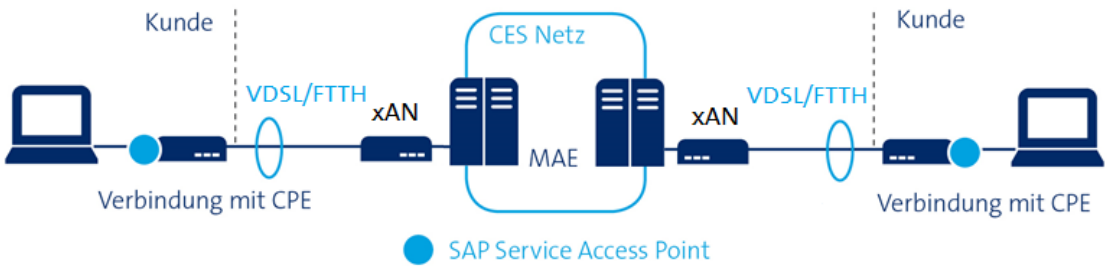

Figure 12: LEx access with CPE

2. Swisscom always terminates the LEC/LEF access at the customer site with a CPE (LEC or LEF-CPE). Direct Connect is not available for LEC/LEF access types.

3. Per CES LE-Access is only 1 CES Connectivity supported.

4. The following interfaces are realised with the LEC or LEF-CPE:

Connection type	Interface bandwidth	Interface type
LEC-CPE	Gigabit Ethernet	10/100/1000Base-T, 1000Base-SX, 1000Base-LX/LH or 1000Base-ZX
LEF-CPE	Gigabit Ethernet	10/100/1000Base-T

Table 8: Overview of CPE and interface type for LEC/LEF

5. The LEC/LEF access type is determined by Swisscom based on the available infrastructure and on the interfaces/bandwidth requested by the PTS.

6. Bandwidth upgrades are only possible up to the maximum LEC/LEF access profile (e.g. 20 Mbit/s for LEC or 1 Gbit/s for LEF). For bandwidth upgrades in excess of the maximum LEC/LEF access profile (i.e. migrations from LEC/LEF access to HE access), is a new HE access necessary.

7. **Low-End Copper CPE (LEC CPE)**

The SAP is located on the physical LAN-side Ethernet interface of the CPE, where the service is made available:

8 x 1 Gigabit Ethernet LAN	10/100/1000Base-T (Cat-5 UTP RJ-45-Stecker)
AC Power 230 VAC	Single
Uplink (WAN)	VDSL
Assembly	19” rack / frame / wall
High	1 Rack unit

8. **Low-End Fiber CPE (LEF CPE) – Available in future release**

The SAP is located on the physical LAN-side Ethernet interface of the CPE, where the service is made available:

2 x 1 Gigabit Ethernet LAN	10/100/1000Base-T (Cat-5 UTP RJ-45-Stecker), 1000Base-SX (MMF LC-Stecker), 1000Base-LX/LH (SMF LC-Stecker), 1000Base-ZX (SMF LC-Stecker)
AC Power 230 VAC	Single
Uplink (WAN)	1 x 1 Gigabit Ethernet
Assembly	19” rack / frame / wall
High	1 Rack unit

2.10 Physical Ethernet interface

Physical medium	LAN Port Auto-negotiation	LAN Port Speed	LAN Port Duplex
10/100BASE-TX	Yes	Auto	Auto
	No	100 Mbit/s	Full
10/100/1000BASE-T	Yes	Auto	Auto
	No	100 Mbit/s or 1000 Mbit/s	Full
1000BASE-SX 1000BASE-LX/LH 1000BASE-ZX	Yes	Not Applicable	Not Applicable
	No	Not Applicable	Not Applicable
10GBASE-SR 10GBASE-LR 10GBASE-ER	Not Applicable	Not Applicable	Not Applicable

Table 9: Physical Ethernet interface

1 Physical medium with 10Base-T and Half-Duplex LAN ports are not offered with CES.

2. If the course of a problem can be traced back to the incorrect configuration of a physical Ethernet interface, the PTS is definitely responsible for a degraded service.

2.11 Port overbooking

1. The PTS can overbook the SAP by up to four times the physical port speed (port overbooking). The total CAR provided is therefore up to four times larger than the physical SAP. Port overbooking is only possible with High-End optical fibre access.
2. Swisscom is not responsible for frame loss or delay caused by an overloaded SAP (SAP congestion).

2.12 Hardware and software updates

1. A service interruption may be needed to perform a hardware or software update. The PTS will be informed accordingly.

2.13 Requirements vis-à-vis the PTS infrastructure

1. The PTS may only attach equipment to the interfaces that complies (at a minimum) with the standards EN 300 386 [1] and EN 302 099 [2].
2. If these standards are not complied with, and this results in damage to the equipment of Swisscom, the PTS must make an appropriate compensation payment.
3. If these standards are not complied with, and interruptions are provoked as a result of this, Swisscom is permitted to deactivate the connection with immediate effect.

3 Technical Reference

3.1 Traffic parameters

1. Incoming customer traffic at the SAP is subjected to an access control check based on the following parameters:
   - Committed Information Rate (CIR) = the service frames are transmitted in accordance with the performance targets up to this average rate
   - Committed Burst Size (CBS) = the service frames are transmitted in a burst in accordance with the performance targets up to this maximum number of bytes
   - Excess Information Rate (EIR) = the service frames are transmitted, without complying with the performance targets, up to this average rate, which can be larger or equal to the CIR
   - Excess Burst Size (CBS) = the service frames are transmitted in a burst, without complying with the performance targets, up to this maximum number of bytes
2. Service frames can be sent via the CES network up to the permitted CIR rate. Service frames that do not comply with the bandwidth profile are rejected (no EIR or EBS available).

CIR Mbit/s	CBS MBytes	EIR Mbit/s	EBS MBytes
1	0.1	0	0
2	0.2	0	0
3	0.3	0	0
4	0.4	0	0
5	0.5	0	0
6	0.6	0	0
8	0.8	0	0
10	1	0	0
15	1.5	0	0
25	2.5	0	0
30	3	0	0
35	3.5	0	0
50	5	0	0
70	7	0	0
100	10	0	0
300	30	0	0
500	50	0	0
700	70	0	0
1000	100	0	0
2000	200	0	0
3000	300	0	0
5000	500	0	0
10000	900	0	0

Table 10: Traffic parameters (CIR, CBS, EIR, EBS)

3.2 Usable Ethernet payload

1. CES provides a certain amount of bandwidth per CES Connectivity point at a location, which corresponds with the symmetrical access bandwidth according to OSI model layer 2. The CAR is specified at the OSI model layer 2 and includes the entire Ethernet overhead.
   - Frame Header (H)
   - Frame Trailer (T)
   - Preamble
   - Minimum Inter-Frame Gap (IFG)
2. The net Ethernet overhead and the usable Ethernet payload bandwidth are dependent on the frame size. Table 11: Example of usable Ethernet payload bandwidth in Mbit/s for EVPL service with Trunking port type (C-Tagged).
   shows the usable theoretical Ethernet payload bandwidths based on frame size and the CAR in the Swisscom network.

CES Connectivity CAR (Mbit/s)	Frame Size (including header/trailer) [Bytes]								
	64	128	256	1024	1522	1794	2048	4400	9000
	Usable Ethernet **payload** bandwidth [Mbit/s]								
2	1.05	1.47	1.72	1.86	1.93	1.95	1.96	1.96	1.98
4	2.1	2.94	3.44	3.71	3.85	3.9	3.92	3.93	3.97
6	3.15	4.42	5.16	5.57	5.78	5.85	5.87	5.89	5.95
8	4.2	5.89	6.88	7.42	7.71	7.8	7.83	7.85	7.93
10	5.25	7.36	8.6	9.28	9.63	9.75	9.79	9.82	9.91
20	10.5	14.72	17.21	18.56	19.27	19.51	19.58	19.63	19.83
30	15.75	22.08	25.81	27.84	28.9	29.26	29.37	29.45	29.74
50	26.25	36.81	43.01	46.4	48.17	48.76	48.95	49.08	49.57
70	36.75	51.53	60.22	64.96	67.44	68.27	68.53	68.71	69.4
100	52.5	73.61	86.03	92.8	96.35	97.53	97.9	98.16	99.14
200	105	147.22	172.06	185.61	192.69	195.06	195.8	196.32	198.28
300	157.5	220.83	258.09	278.41	289.04	292.59	293.7	294.48	297.42
500	262.5	368.06	430.15	464.02	481.73	487.65	489.5	490.79	495.7
700	367.5	515.28	602.21	649.62	674.42	682.7	685.3	687.11	693.98
1000	525	736.11	860.29	928.03	963.46	975.29	979.01	981.59	991.39
2000	1090.91	1503.55	1739.78	1866.67	1932.5	1954.4	1961.26	1966.04	1984.14
3000	1636.36	2255.32	2609.67	2800	2898.75	2931.6	2941.89	2949.05	2976.21
5000	2727.27	3758.87	4349.44	4666.67	4831.24	4885.99	4903.15	4915.09	4960.34
10000	5454.55	7517.73	8698.88	9333.33	9662.49	9771.99	9806.31	9830.18	9920.69

Table 11: Example of usable Ethernet payload bandwidth in Mbit/s for EVPL service with Trunking port type (C-Tagged).

3. If, as shown in table above, an EVPL service with a CAR of 50 Mbit/s transmits Ethernet frames (C-tagged) with an average length of 1024 bytes, an average bandwidth of 48.17 Mbit/s is available for the payload (e.g. IP packets).