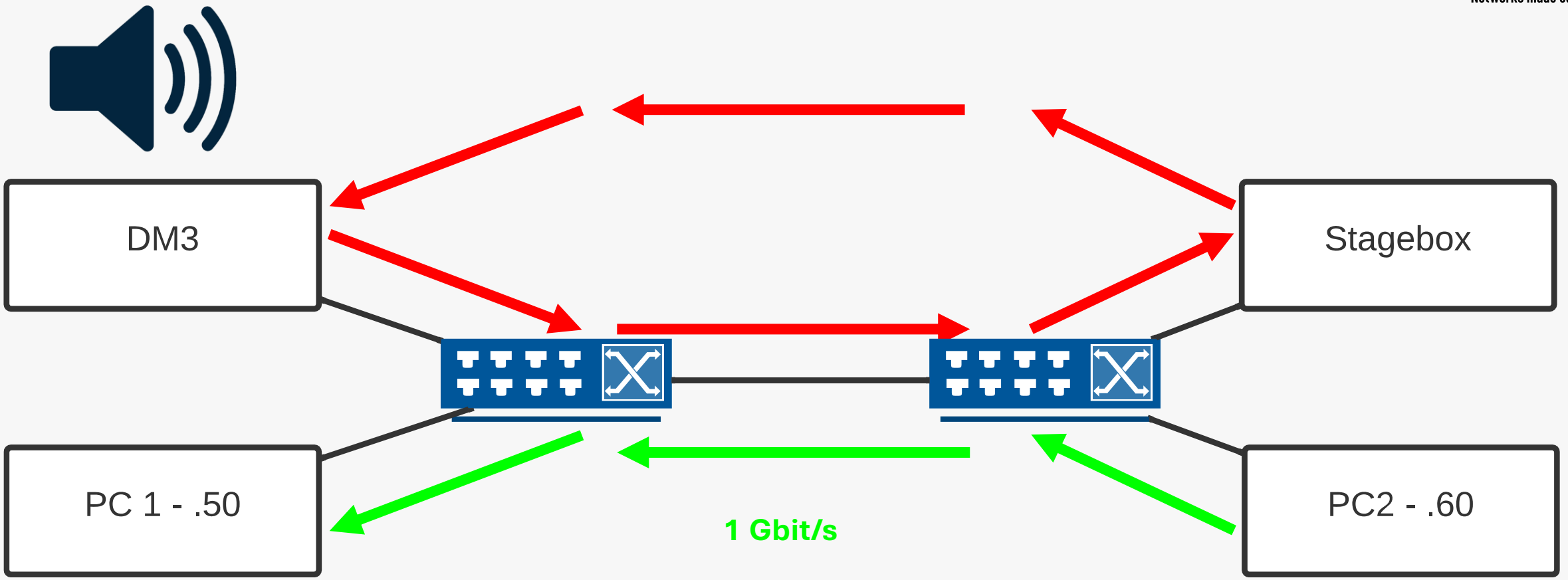
Was ist Quality-Of-Service?

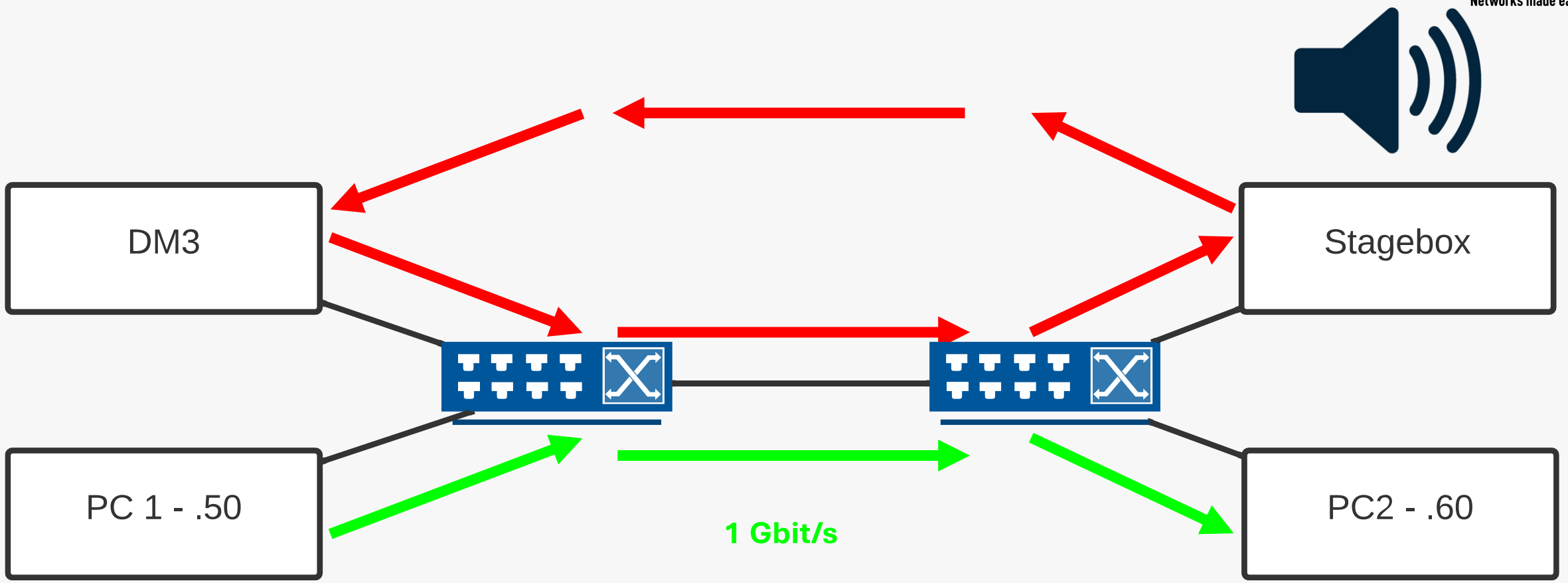
Überbegriff für die Priorisierung von Datenverkehr

Wofür brauchen wir Quality-Of-Service?

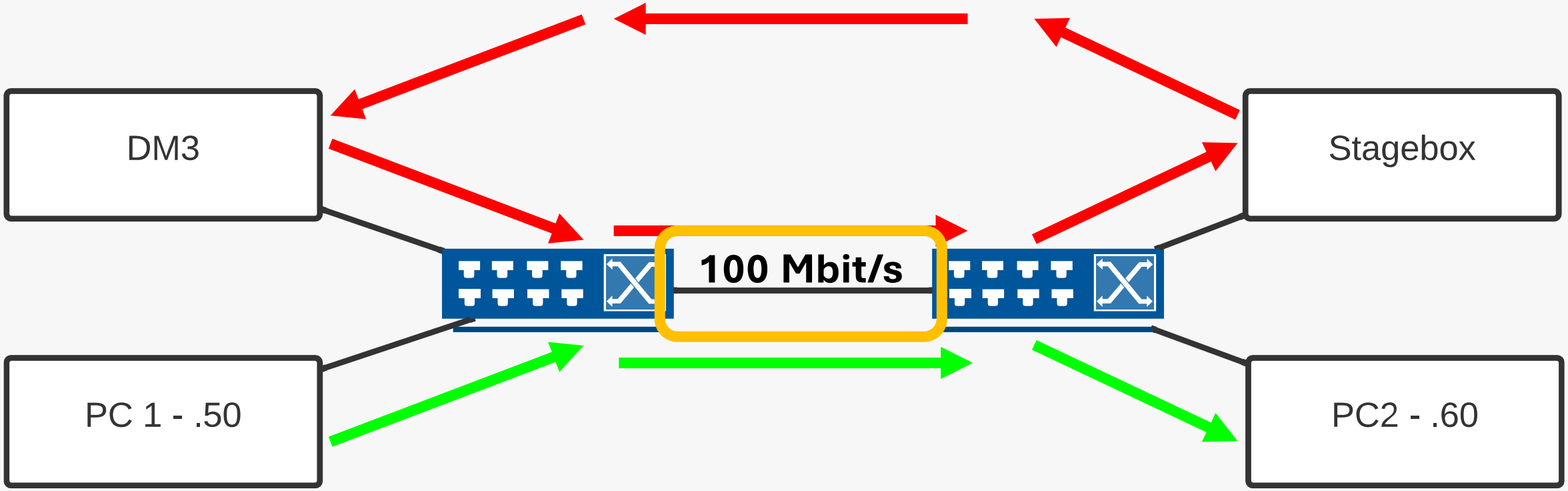
Wir wollen die Qualität einer Anwendung sicherstellen!

Beispiel: Hohe Auslastung

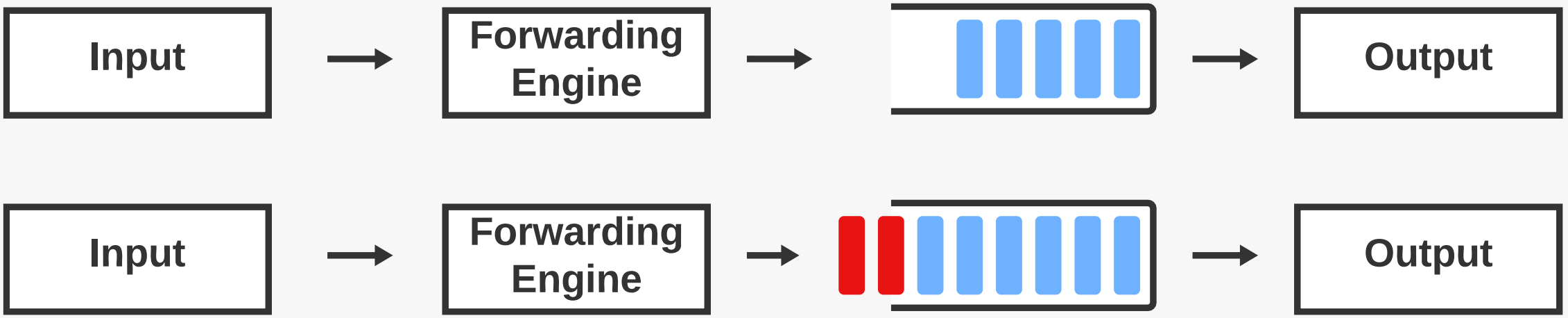

DM3
Stagebox
PC 1 - .50
PC2 - .60
1 Gbit/s


DM3
Stagebox
PC 1 - .50
PC2 - .60
1 Gbit/s

Beispiel: 1Gbit/s auf 100Mbit/s


DM3
Stagebox
100 Mbit/s
PC 1 - .50
PC2 - .60


Input
Forwarding Engine
Output


Input
Forwarding Engine
Output
Input
Forwarding Engine
Output

Marking

Markieren von Paketen

Queuing

Paketsortierung und Priorisierung

Policing

Bandbreiten Limitierung

Shaping

Bandbreiten Limitierung mit Warteschlangen

Classification

Einordnung von Paketen in Klassen

Congestion Avoidance

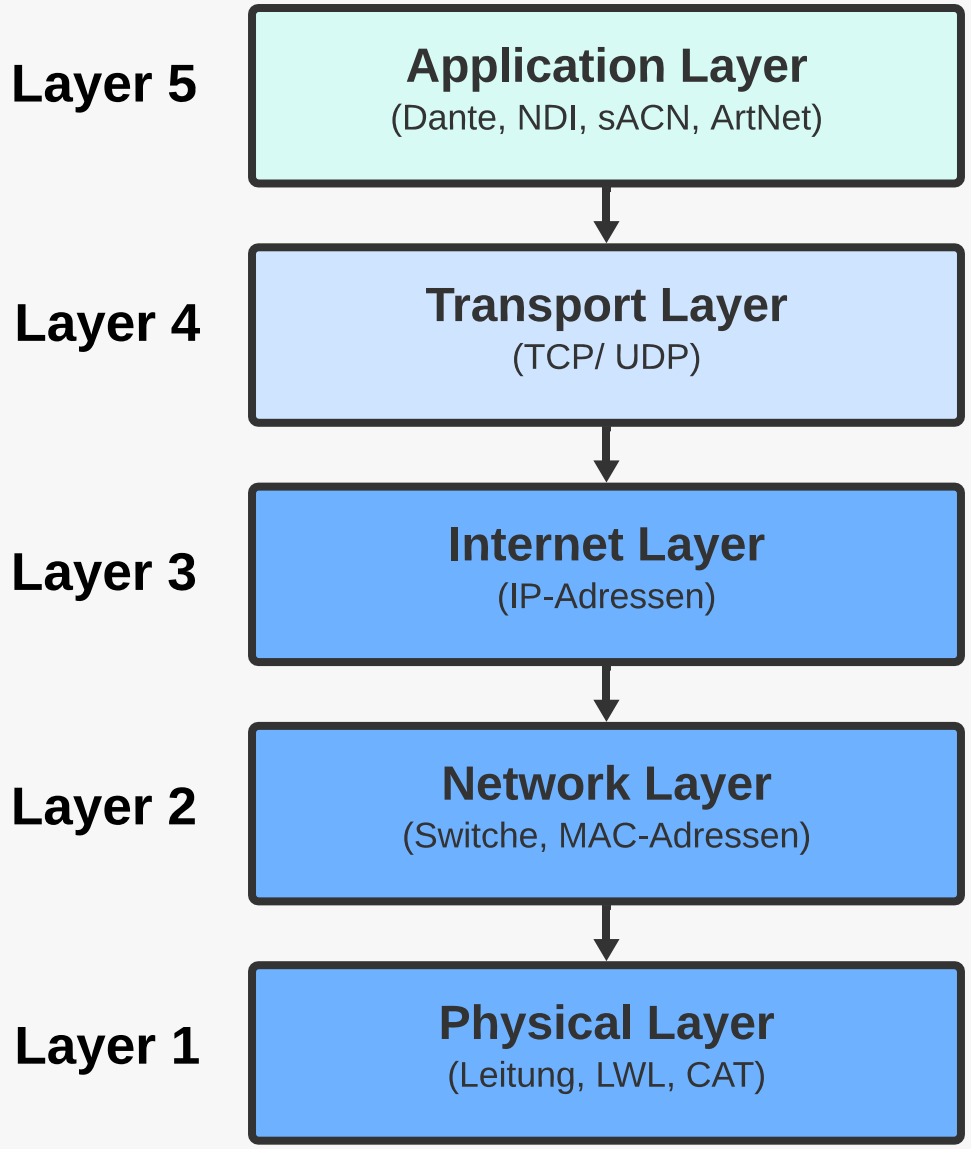
Stau Vermeidung

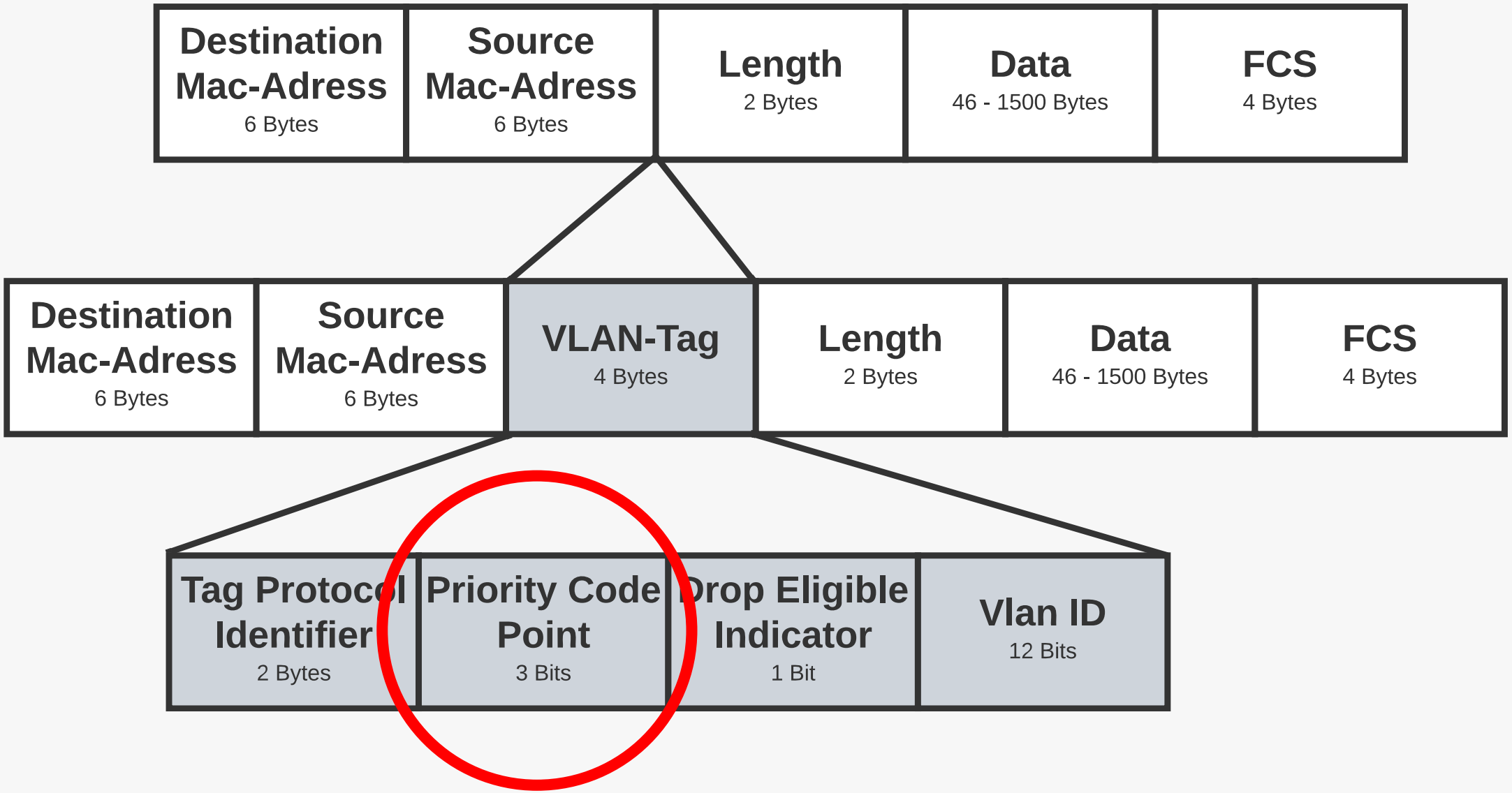
Marking

Markieren von Paketen

Class-Of-Service!

Layer 2 Identifikation von Datenverkehr


Layer 5
Application Layer
(Dante, NDI, sACN, ArtNet)
Layer 4
Transport Layer
(TCP/ UDP)
Layer 3
Internet Layer
(IP-Adressen)
Layer 2
Network Layer
(Switche, MAC-Adressen)
Layer 1
Physical Layer
(Leitung, LWL, CAT)


Destination Mac-Adress
6 Bytes
Source Mac-Adress
6 Bytes
Length
2 Bytes
Data
46 - 1500 Bytes
FCS
4 Bytes
Destination Mac-Adress
6 Bytes
Source Mac-Adress
6 Bytes
VLAN-Tag
4 Bytes
Length
2 Bytes
Data
46 - 1500 Bytes
FCS
4 Bytes
Tag Protocol Identifier
2 Bytes
Priority Code Point
3 Bits
Drop Eligible Indicator
1 Bit
Vlan ID
12 Bits

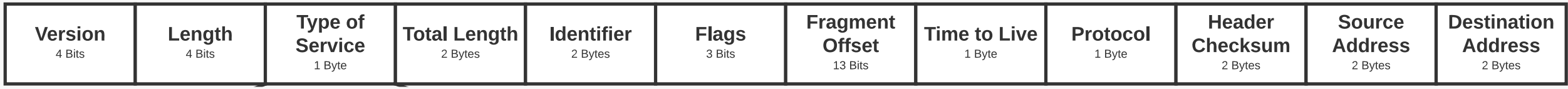
Networks made easy!

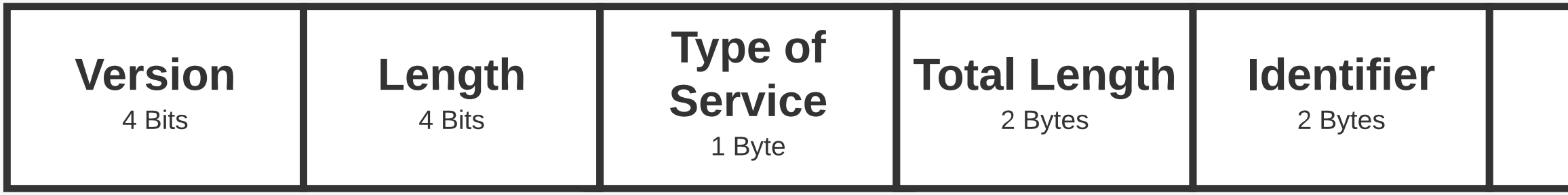
Priorität steigt

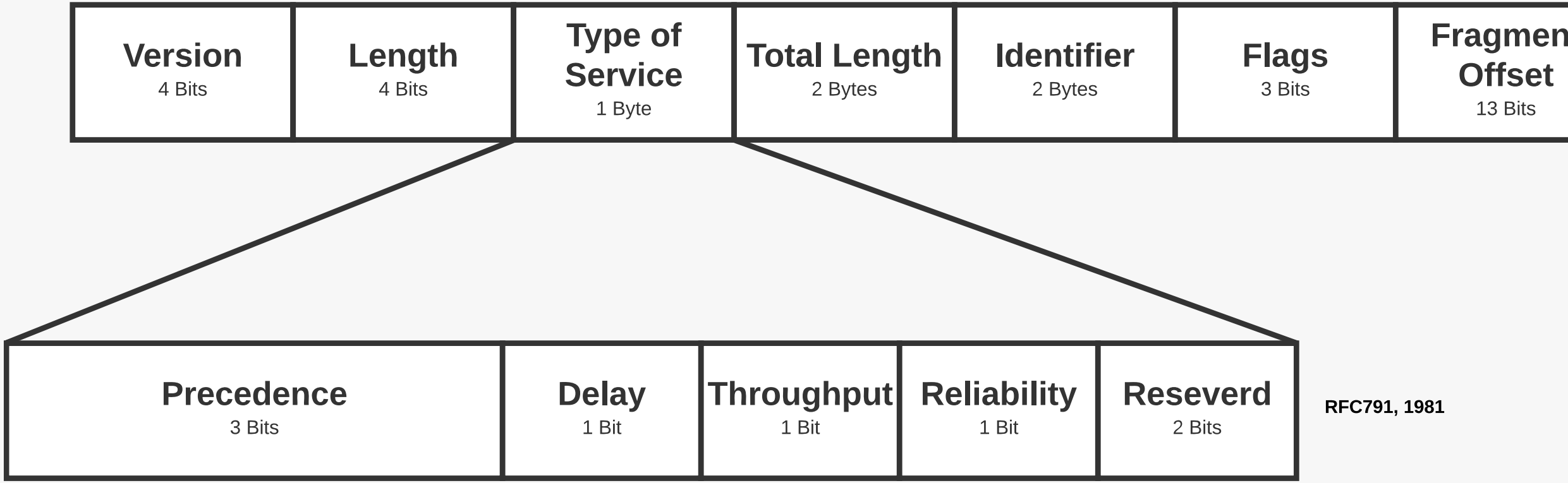
Priority Code Point	Anwendung
0	Best effort (Standard)
1	Hintergrund
2	Netzwerk Managment
3	Kritische Daten
4	Video
5	Audio
6	Routing
7	Audio

Type-Of-Service!

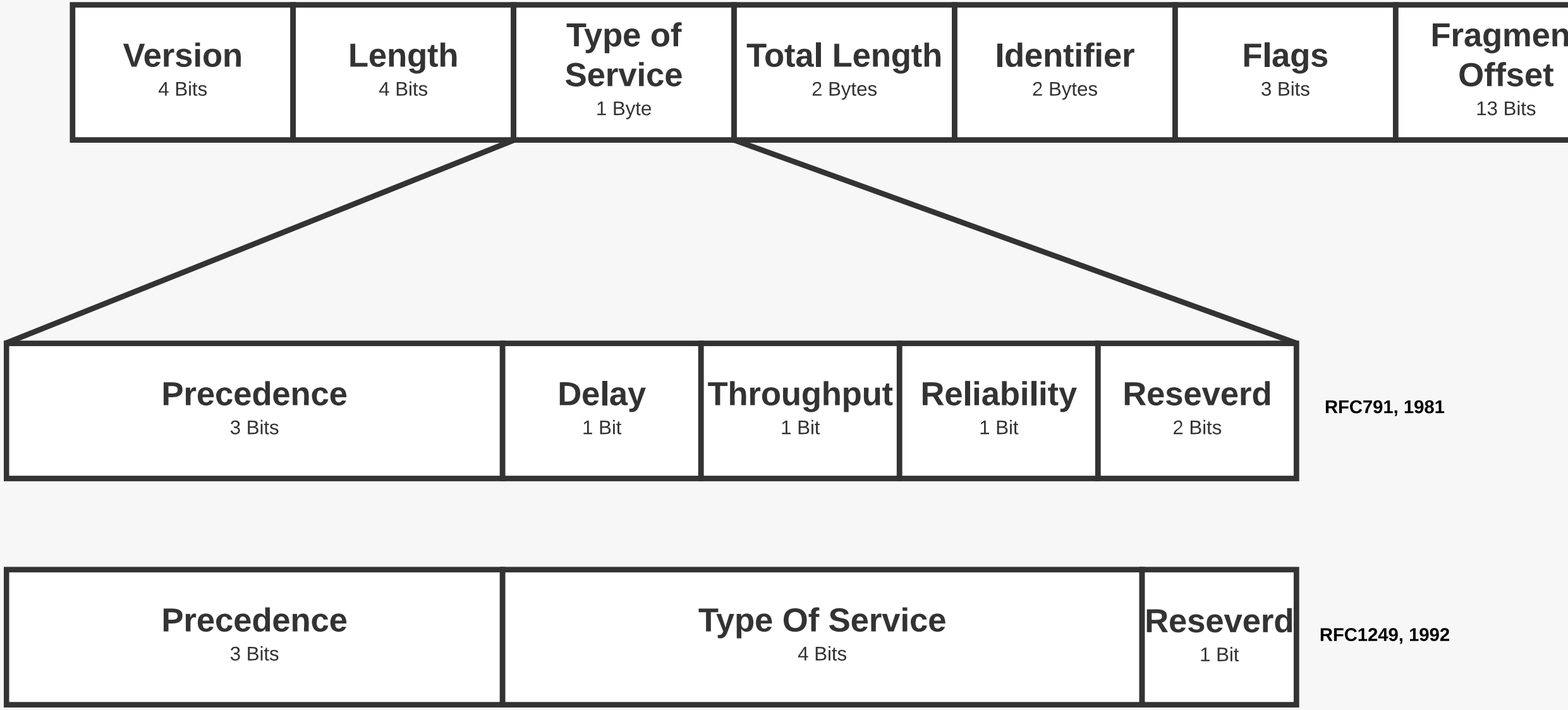
Alte Layer 3 Identifikation von Datenverkehr


Version
4 Bits
Length
4 Bits
Type of Service
1 Byte
Total Length
2 Bytes
Identifier
2 Bytes
Flags
3 Bits
Fragment Offset
13 Bits
Time to Live
1 Byte
Protocol
1 Byte
Header Checksum
2 Bytes
Source Address
2 Bytes
Destination Address
2 Bytes


Version
4 Bits
Length
4 Bits
Type of Service
1 Byte
Total Length
2 Bytes
Identifier
2 Bytes

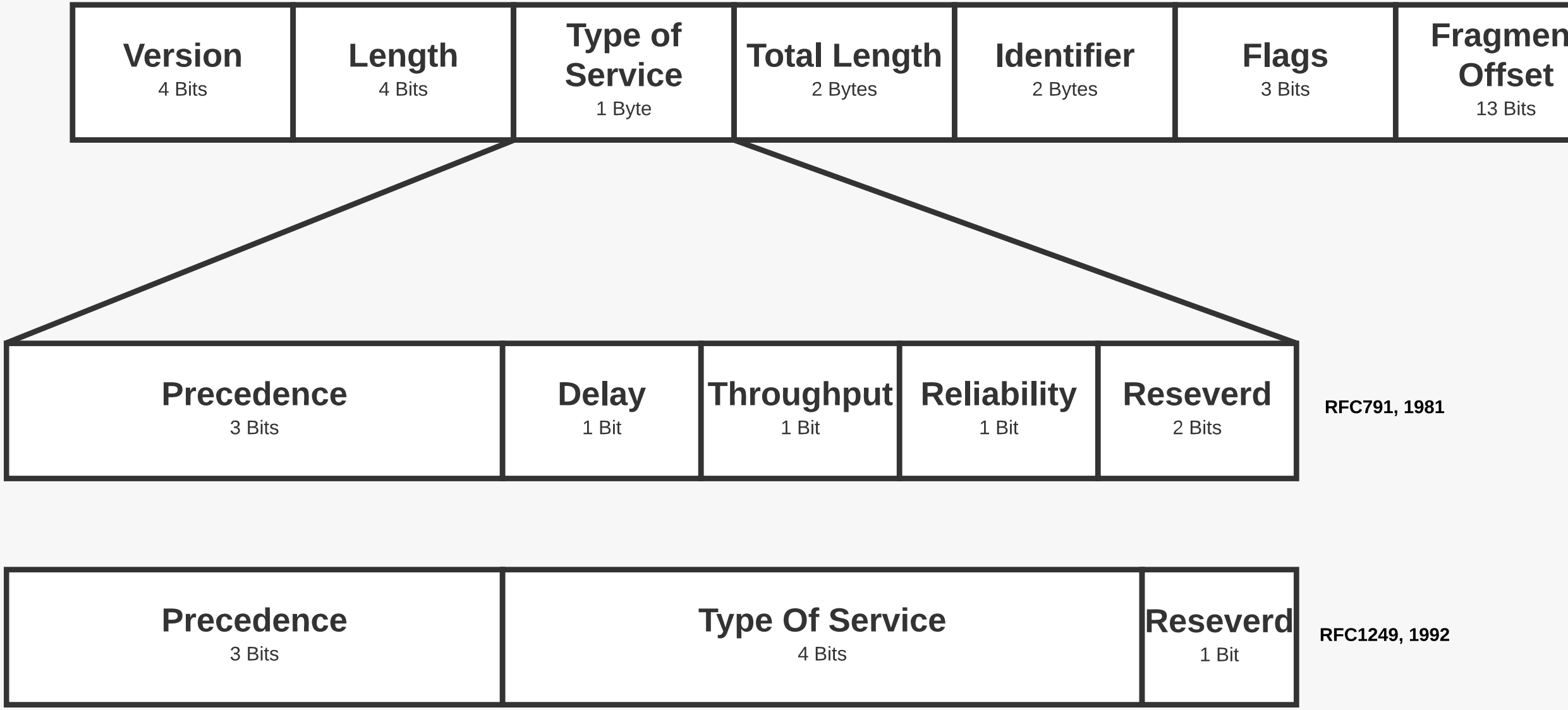

Version
4 Bits
Length
4 Bits
Type of Service
1 Byte
Total Length
2 Bytes
Identifier
2 Bytes
Flags
3 Bits
Fragmen
Offset
13 Bits
Precedence
3 Bits
Delay
1 Bit
Throughput
1 Bit
Reliability
1 Bit
Reseverd
2 Bits

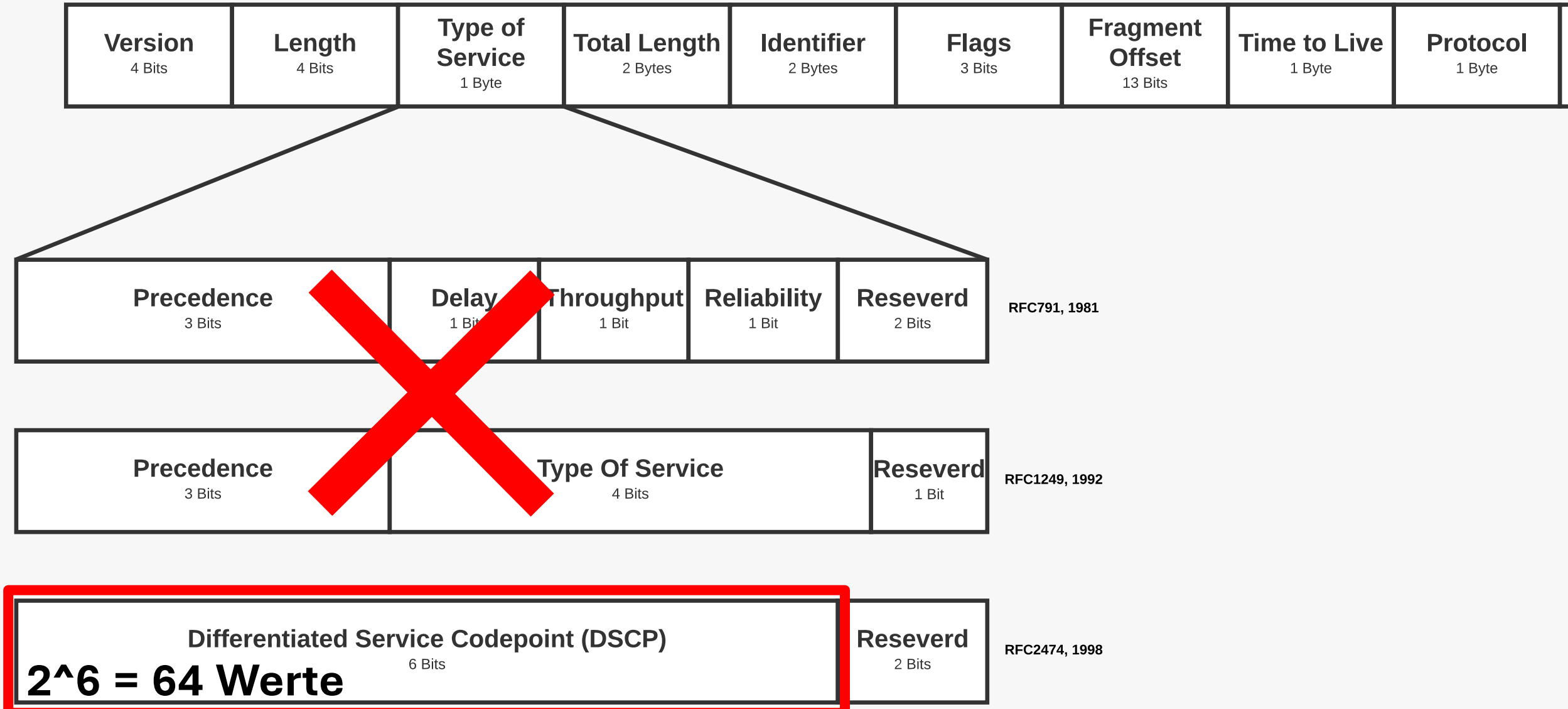
RFC791, 1981


Version
4 Bits
Length
4 Bits
Type of Service
1 Byte
Total Length
2 Bytes
Identifier
2 Bytes
Flags
3 Bits
Fragmen
Offset
13 Bits
Precedence
3 Bits
Delay
1 Bit
Throughput
1 Bit
Reliability
1 Bit
Reseverd
2 Bits
RFC791, 1981
Precedence
3 Bits
Type Of Service
4 Bits
Reseverd
1 Bit
RFC1249, 1992

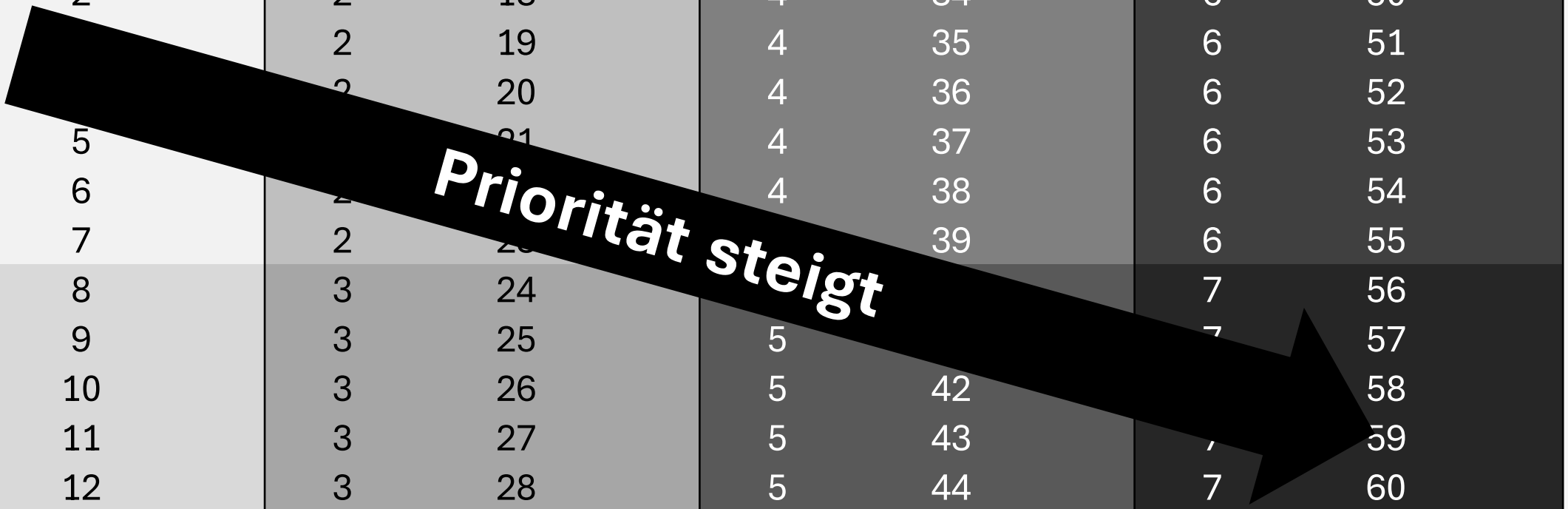
Was ist DiffServe?

Neue Layer 3 Identifikation von Datenverkehr


Version
4 Bits
Length
4 Bits
Type of Service
1 Byte
Total Length
2 Bytes
Identifier
2 Bytes
Flags
3 Bits
Fragmen
Offset
13 Bits
Precedence
3 Bits
Delay
1 Bit
Throughput
1 Bit
Reliability
1 Bit
Reseverd
2 Bits
RFC791, 1981
Precedence
3 Bits
Type Of Service
4 Bits
Reseverd
1 Bit
RFC1249, 1992


Version
4 Bits
Length
4 Bits
Type of Service
1 Byte
Total Length
2 Bytes
Identifier
2 Bytes
Flags
3 Bits
Fragment Offset
13 Bits
Time to Live
1 Byte
Protocol
1 Byte
Precedence
3 Bits
Delay
1 Bit
Throughput
1 Bit
Reliability
1 Bit
Reseverd
2 Bits
RFC791, 1981
Precedence
3 Bits
Type Of Service
4 Bits
Reseverd
1 Bit
RFC1249, 1992
Differentiated Service Codepoint (DSCP)
6 Bits
Reseverd
2 Bits
RFC2474, 1998
2^6 = 64 Werte

CoS/PCP	DSCP-Wert	CoS/PCP	DSCP-Wert	CoS/PCP	DSCP-Wert	CoS/PCP	DSCP-Wert
0	0	2	16	4	32	6	48
0	1	2	17	4	33	6	49
0	2	2	18	4	34	6	50
0		2	19	4	35	6	51
0		2	20	4	36	6	52
0	5	2	21	4	37	6	53
0	6	2		4	38	6	54
0	7	2			39	6	55
1	8	3	24			7	56
1	9	3	25	5		7	57
1	10	3	26	5	42		58
1	11	3	27	5	43	7	59
1	12	3	28	5	44	7	60
1	13	3	29	5	45	7	61
1	14	3	30	5	46	7	62
1	15	3	31	5	47	7	63



Marking

Markieren von Paketen

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Paketsortierung und Priorisierung

Policing

Bandbreiten Limitierung

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Classification

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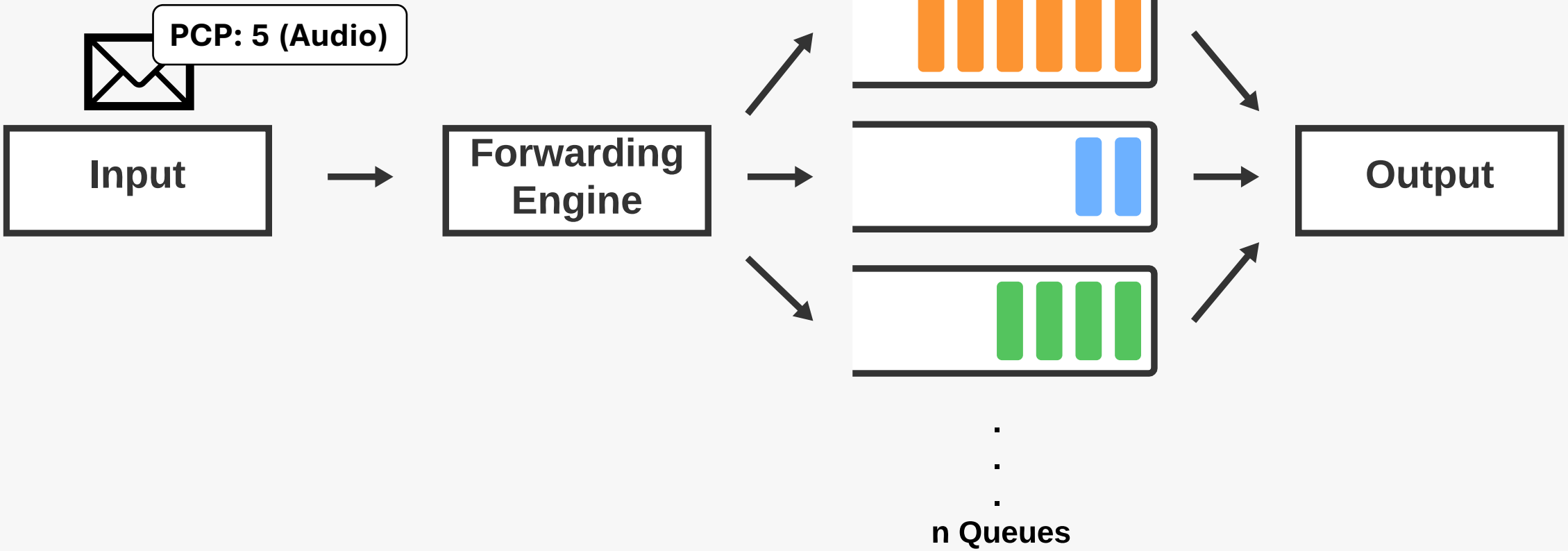
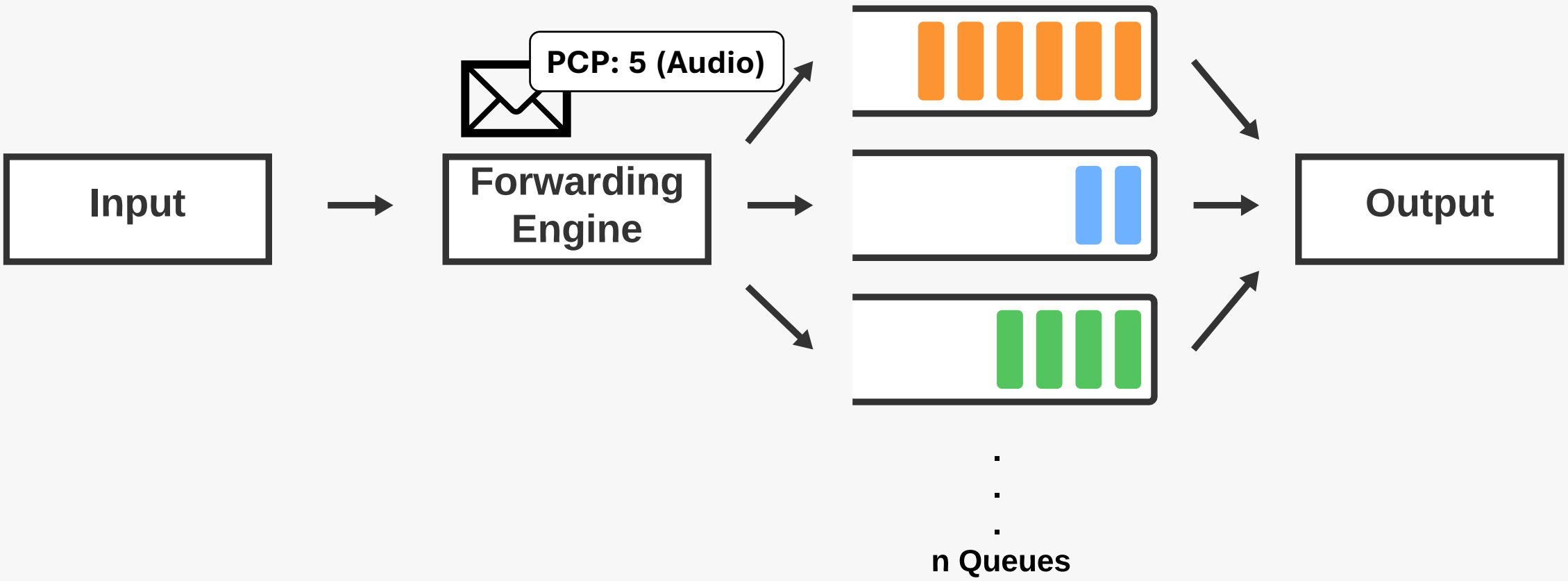
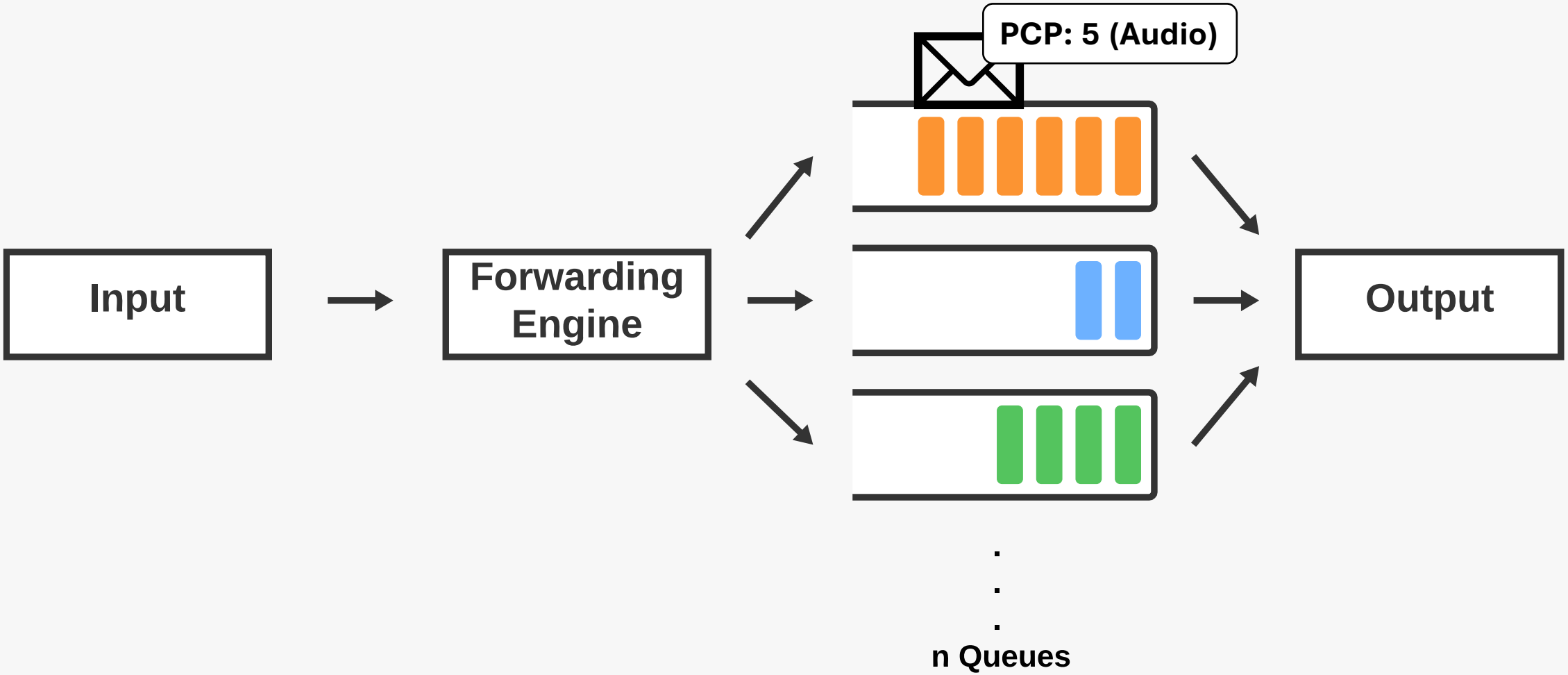
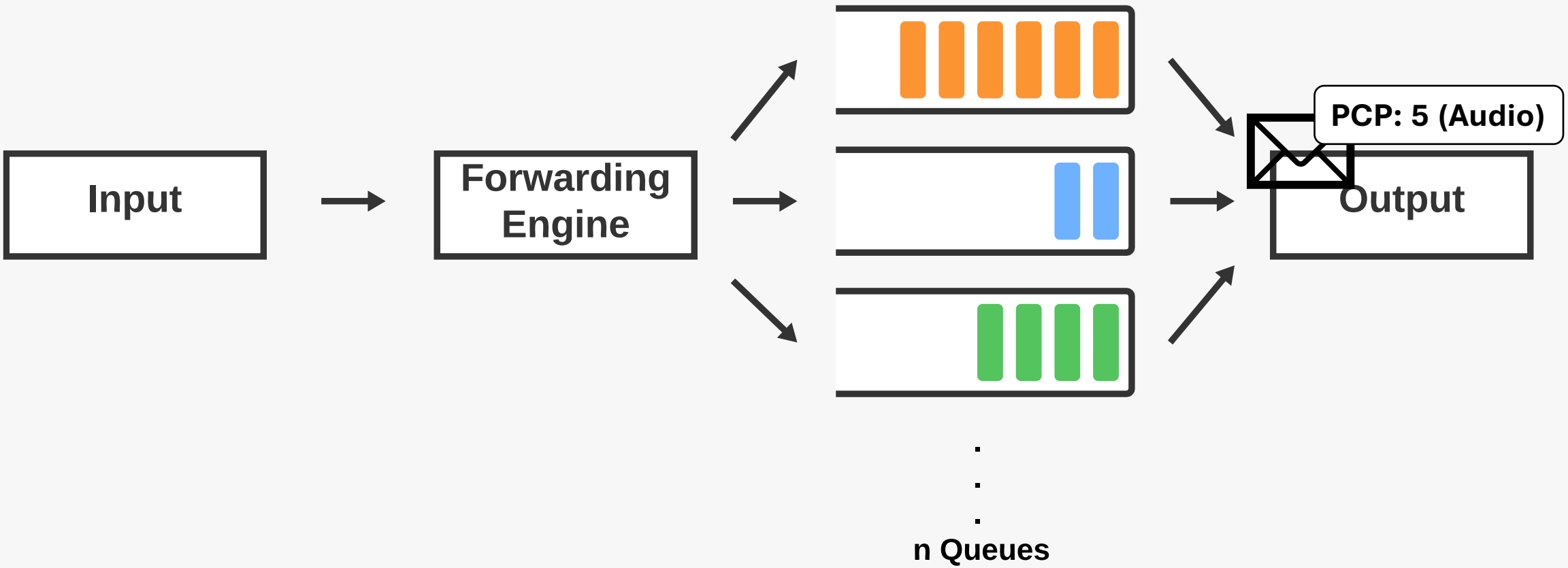
Paketsortierung und Priorisierung


PCP: 5 (Audio)
Input
Forwarding Engine
Output
n Queues


PCP: 5 (Audio)
Input
Forwarding Engine
Output
n Queues


PCP: 5 (Audio)
Input
Forwarding Engine
Output
n Queues


Input
Forwarding Engine
PCP: 5 (Audio)
Output
n Queues

Queuing

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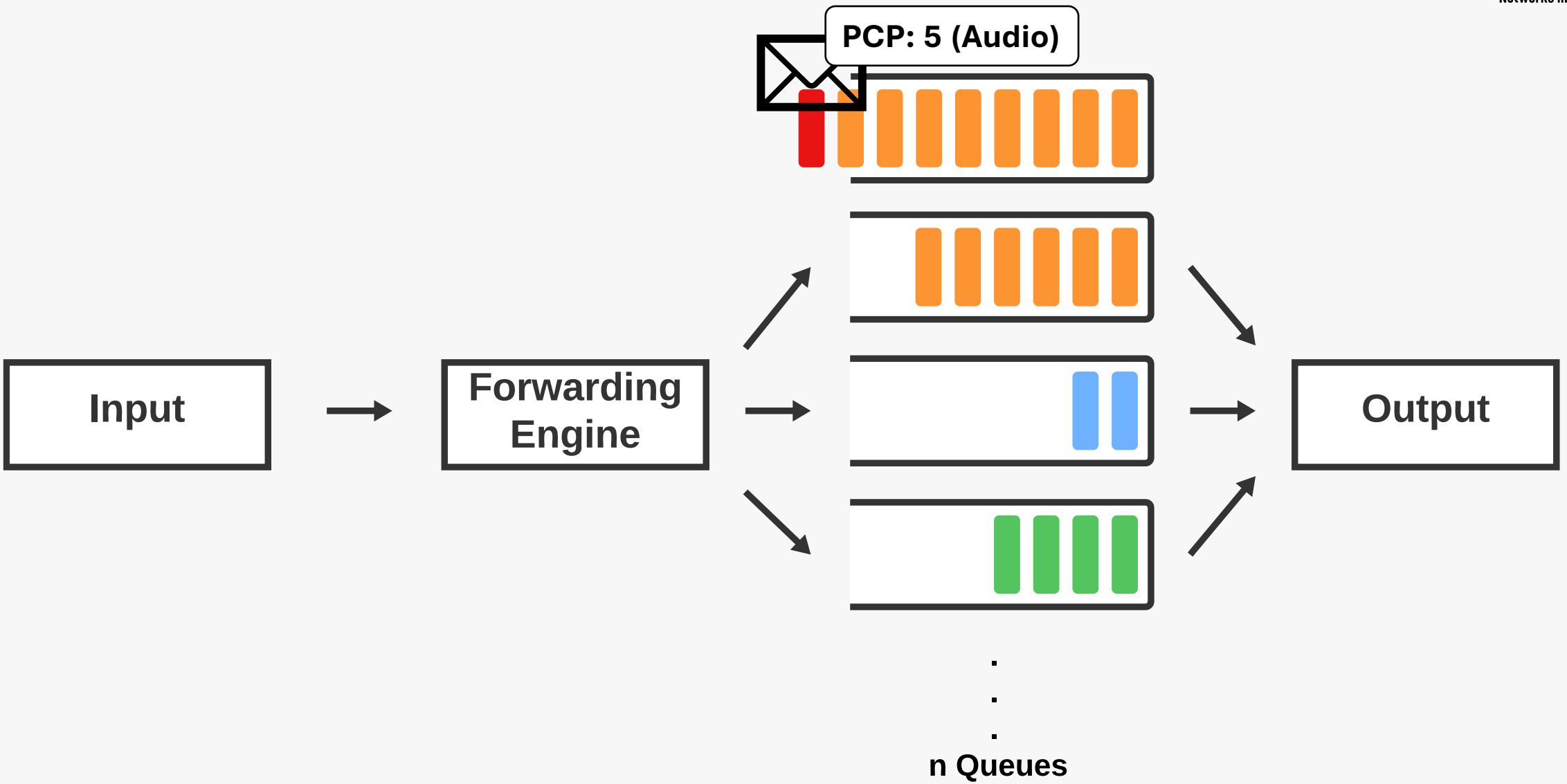
Stau Vermeidung


PCP: 5 (Audio)
Input
Forwarding Engine
Output
n Queues

CoS/PCP	DSCP-Wert	CoS/PCP	DSCP-Wert	CoS/PCP	DSCP-Wert	CoS/PCP	DSCP-Wert
0	0	2	16	4	32	6	48
0	1	2	17	4	33	6	49
0	2	2	18	4	34	6	50
0	3	2	19	4	35	6	51
0	4	2	20	4	36	6	52
0	5	2	21	4	37	6	53
0	6	2	22	4	38	6	54
0	7	2	23	4	39	6	55
1	8	3	24	5	40	7	56
1	9	3	25	5	41	7	57
1	10	3	26	5	42	7	58
1	11	3	27	5	43	7	59
1	12	3	28	5	44	7	60
1	13	3	29	5	45	7	61
1	14	3	30	5	46	7	62
1	15	3	31	5	47	7	63

CoS/PCP	DSCP-Wert	PHB	CoS/PCP	DSCP-Wert	PHB	CoS/PCP	DSCP-Wert	PHB	CoS/PCP	DSCP-Wert	PHB
0	0	*0*	2	16	*CS2*	4	32	*CS4*	6	48	*CS6*
0	1		2	17		4	33		6	49	
0	2		2	18	*AF21*	4	34	*AF41*	6	50	
0	3		2	19		4	35		6	51	
0	4		2	20	*AF22*	4	36	*AF42*	6	52	
0	5		2	21		4	37		6	53	
0	6		2	22	*AF23*	4	38	*AF43*	6	54	
0	7		2	23		4	39		6	55	
1	8	*CS1*	3	24	*CS3*	5	40	*CS5*	7	56	*CS7*
1	9		3	25		5	41		7	57	
1	10	*AF11*	3	26	*AF31*	5	42		7	58	
1	11		3	27		5	43		7	59	
1	12	*AF12*	3	28	*AF32*	5	44		7	60	
1	13		3	29		5	45		7	61	
1	14	*AF13*	3	30	*AF33*	5	46	*EF*	7	62	
1	15		3	31		5	47		7	63	

CoS/PCP	DSCP-Wert	PHB
0	0	*BE*
1	8	*CS1*
1	10	*AF11*
1	12	*AF12*
1	14	*AF13*
2	16	*CS2*
2	18	*AF21*
2	20	*AF22*
2	22	*AF23*
3	24	*CS3*
3	26	*AF31*
3	28	*AF32*
3	30	*AF33*
4	32	*CS4*
4	34	*AF41*
4	36	*AF42*
4	38	*AF43*
5	40	*CS5*
5	46	*EF*
6	48	*CS6*
7	56	*CS7*

BE -> Best Effort -> FIFO

CS -> Class Selectoren -> CoS / PCP

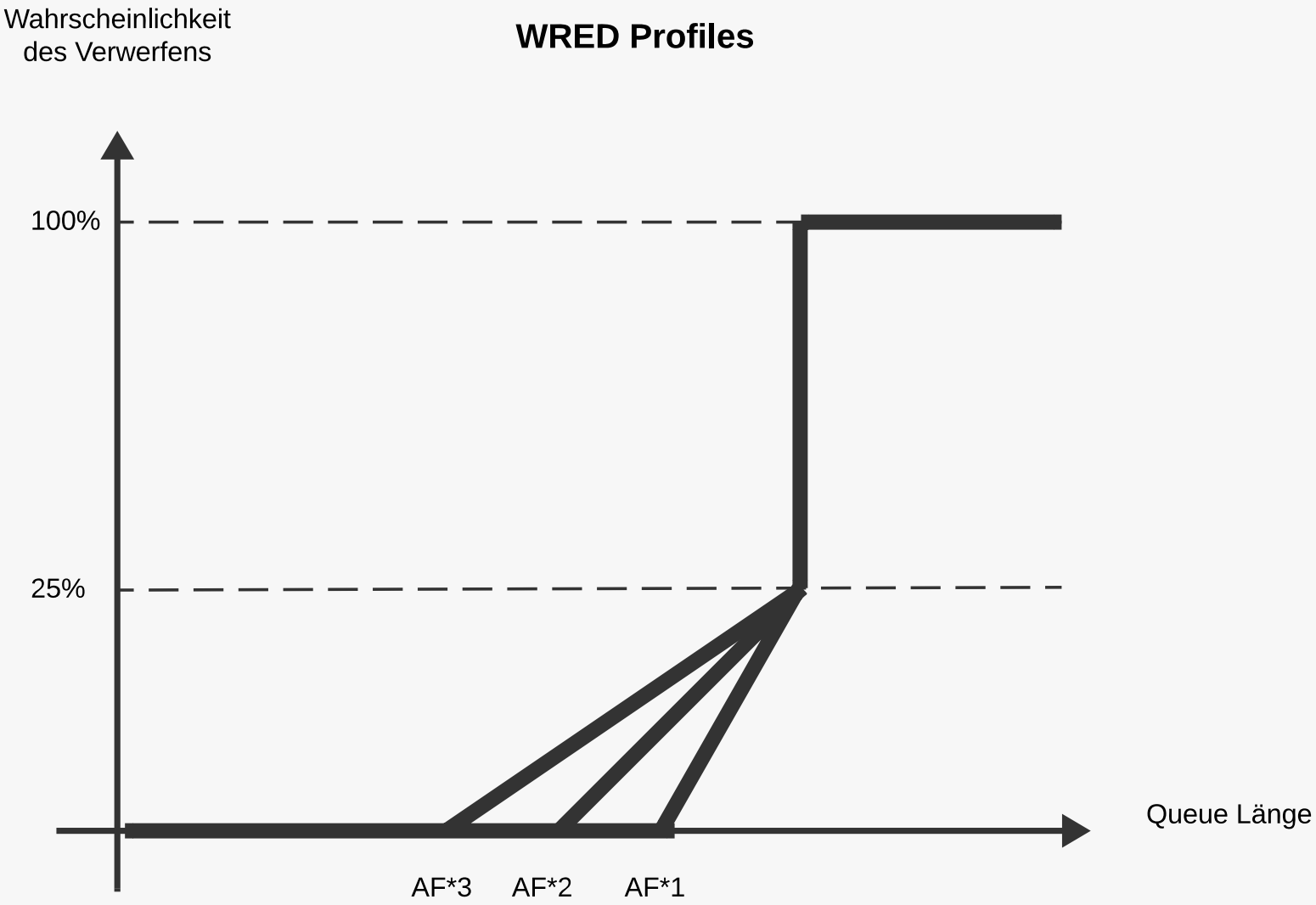
AF -> Assured Forwarding -> Zugesichertes Weiterleiten

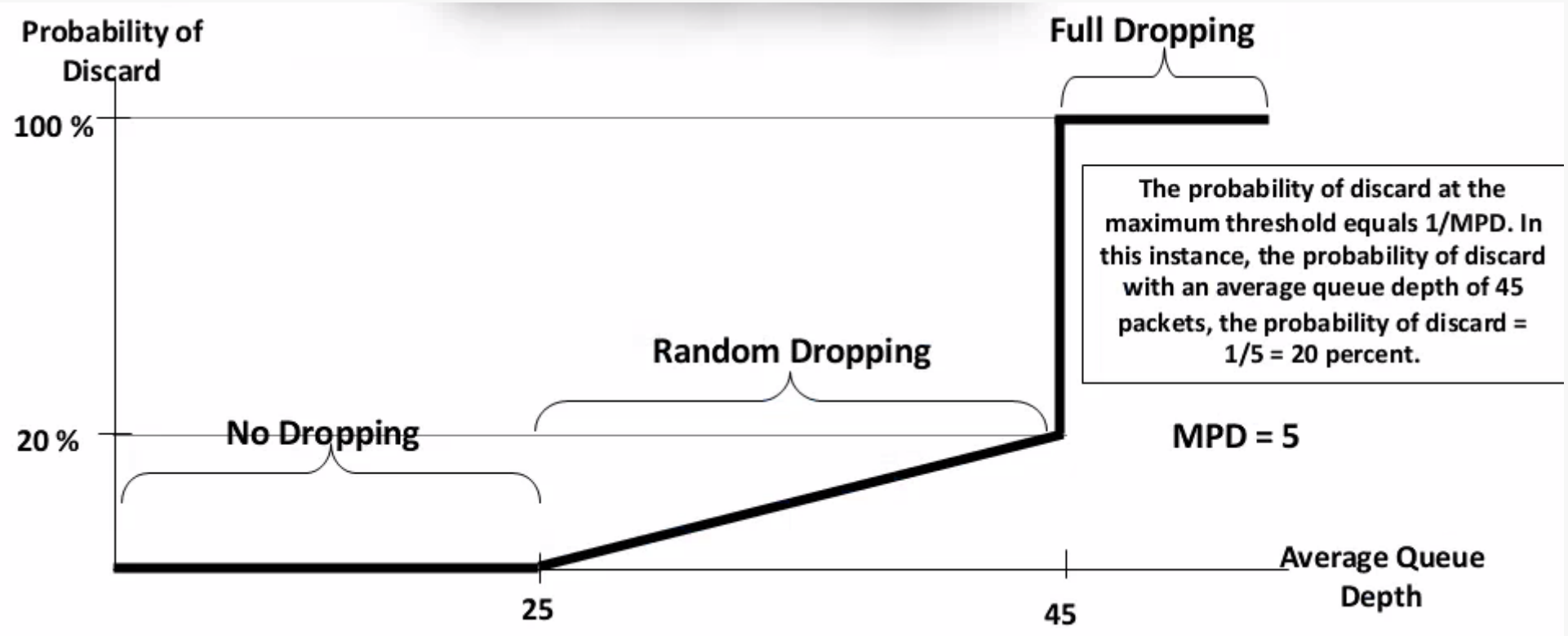
	Queue Class			
Drop Propability	*1*	*2*	*3*	*4*
Low	*AF11*	*AF21*	*AF31*	*AF41*
Medium	*AF12*	*AF22*	*AF32*	*AF42*
High	*AF13*	*AF23*	*AF33*	*AF43*

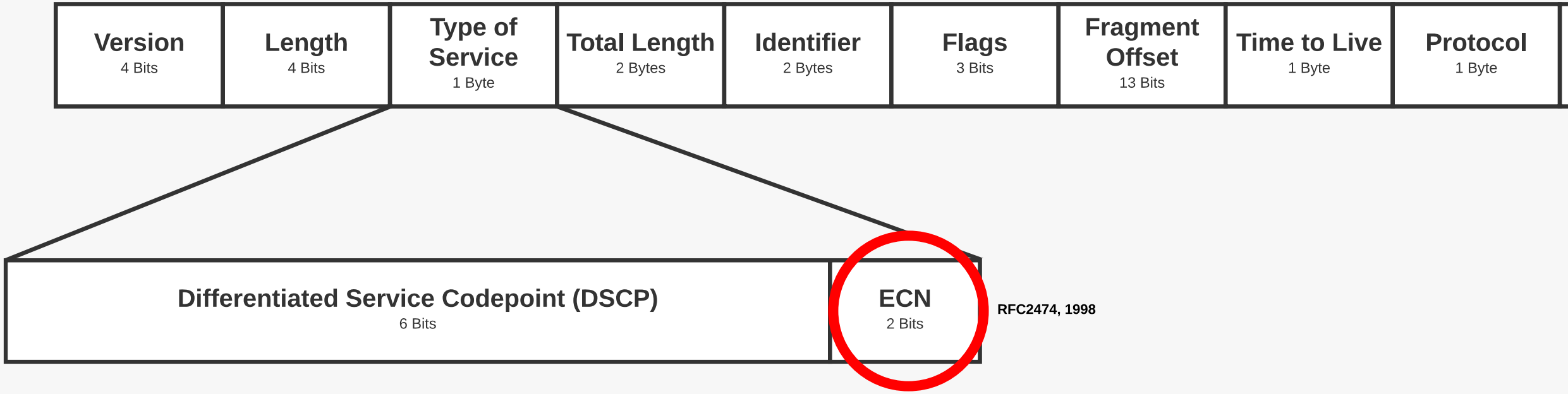
EF -> Expedited Forwarding -> Schnelles Weiterleiten

Assured Forwarding

WRED Profiles




Probability of Discard
100 %
20 %
Full Dropping
Random Dropping
No Dropping
The probability of discard at the maximum threshold equals 1/MPD. In this instance, the probability of discard with an average queue depth of 45 packets, the probability of discard = 1/5 = 20 percent.
MPD = 5
Average Queue Depth
25
45



ECN -> Explicit Congestion Notification

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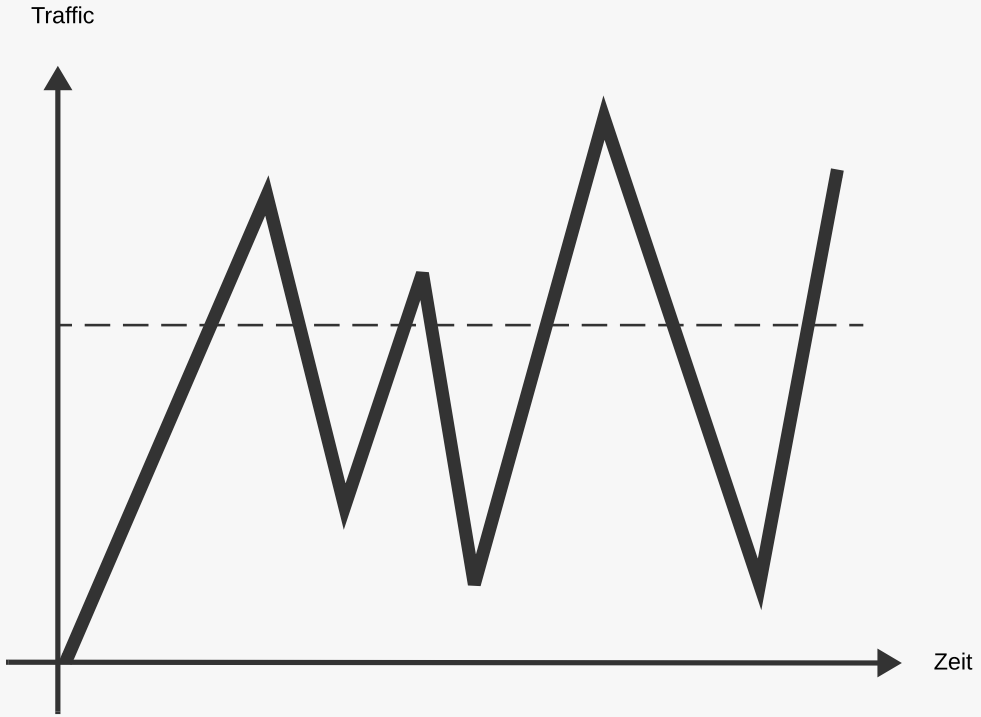
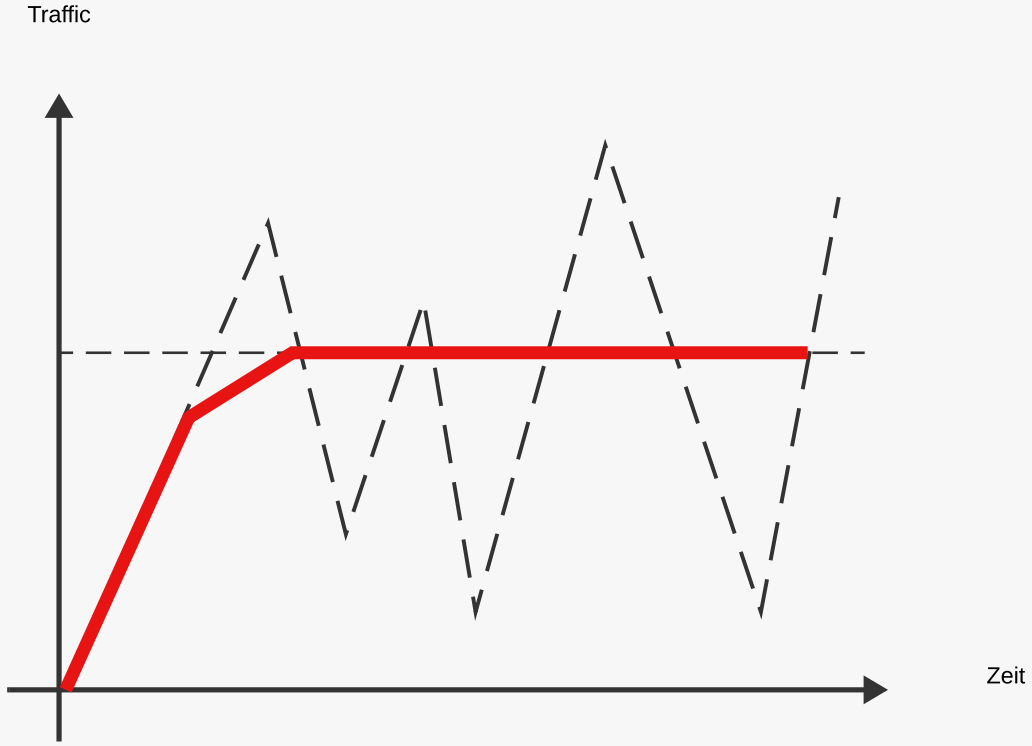

Traffic
Zeit


Traffic
Zeit

Shaping

Bandbreiten Limitierung mit Warteschlangen

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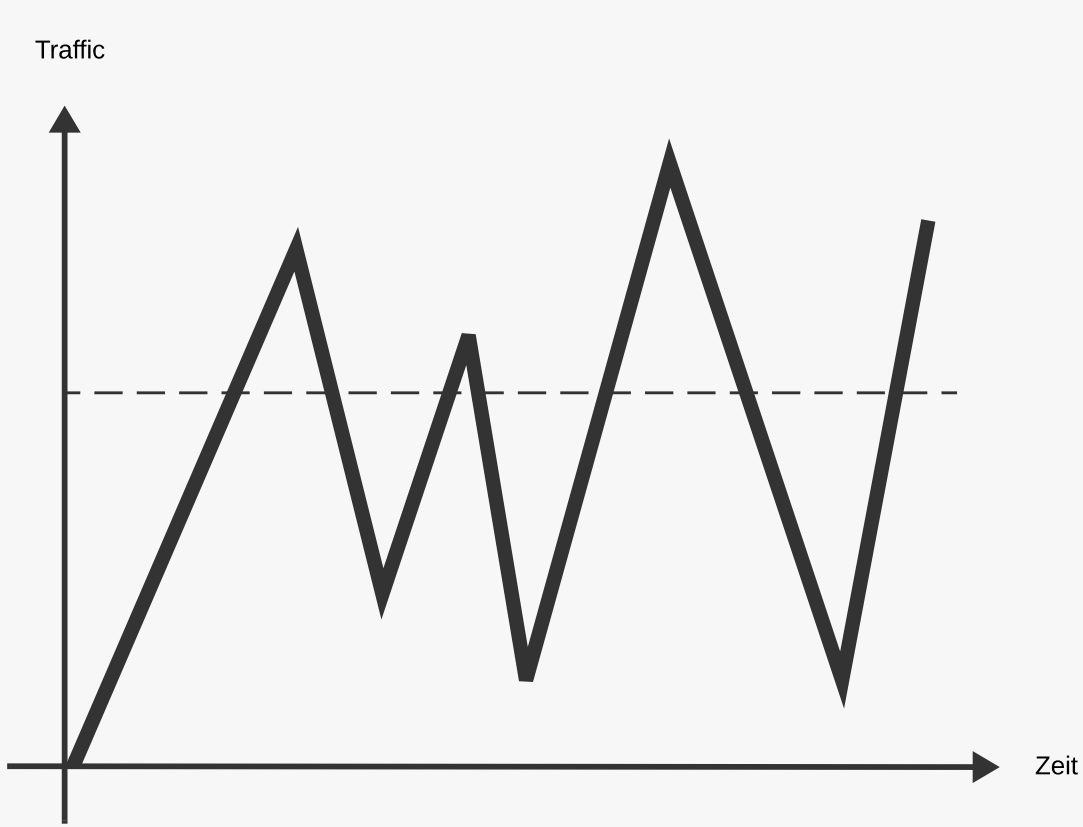
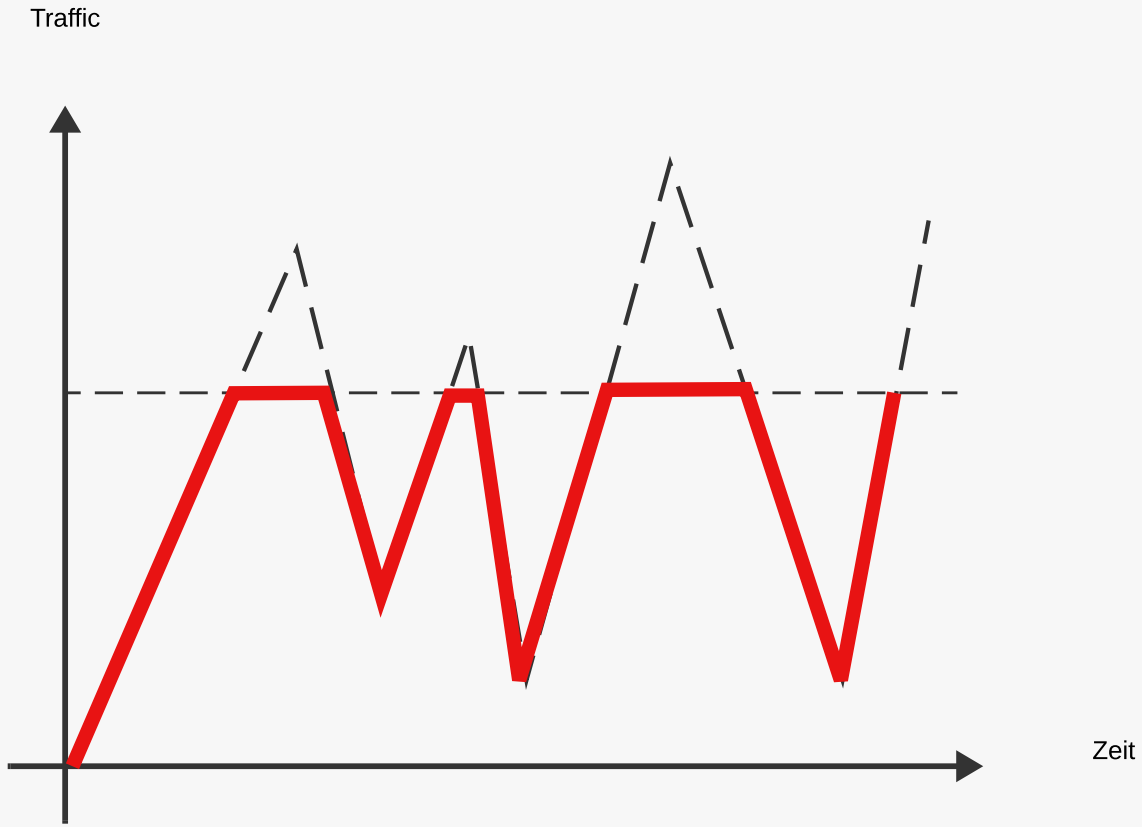
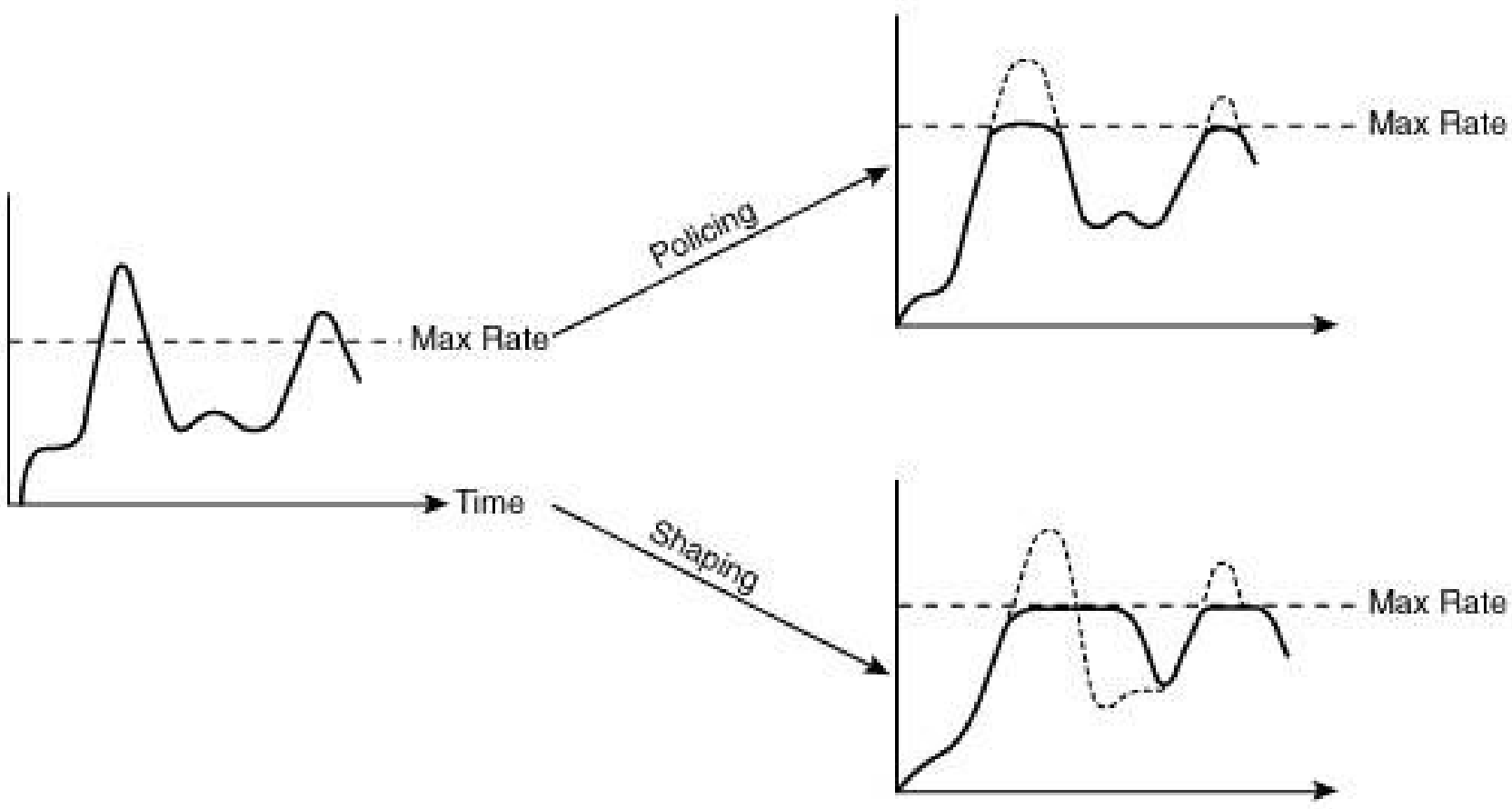

Traffic
Zeit


Traffic
Zeit


Max Rate
Policing
Max Rate
Time
Shaping
Max Rate

Policing

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Einteilung der DSCP Werte in Queues

Priority	Usage	DSCP Label	Hex	Decimal	Binary
High	Time critical PTP events	CS7	0x38	56	111000
Medium	Audio, PTP	EF	0x2E	46	101110
Low	(reserved)	CS1	0x08	8	001000
None	Other traffic	BestEffort	0x00	0	000000

https://www.getdante.com/support/faq/how-does-dante-use-dscp-diffserv-priority-values-when-configuring-qos/

DEMO: Basic QoS Konfig für PTP auf Cisco

DSCP Wert von 56 auf High Priority

1

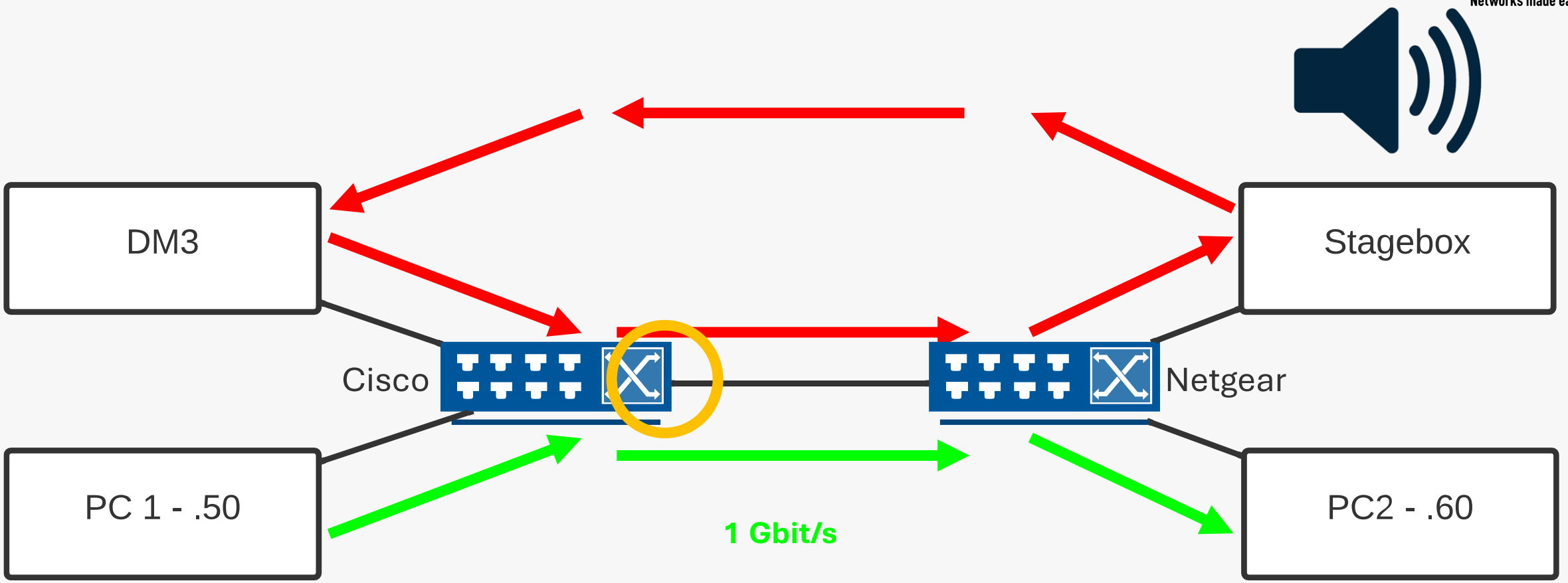
QoS aktivieren

2

Trust-Mode auf DSCP

3

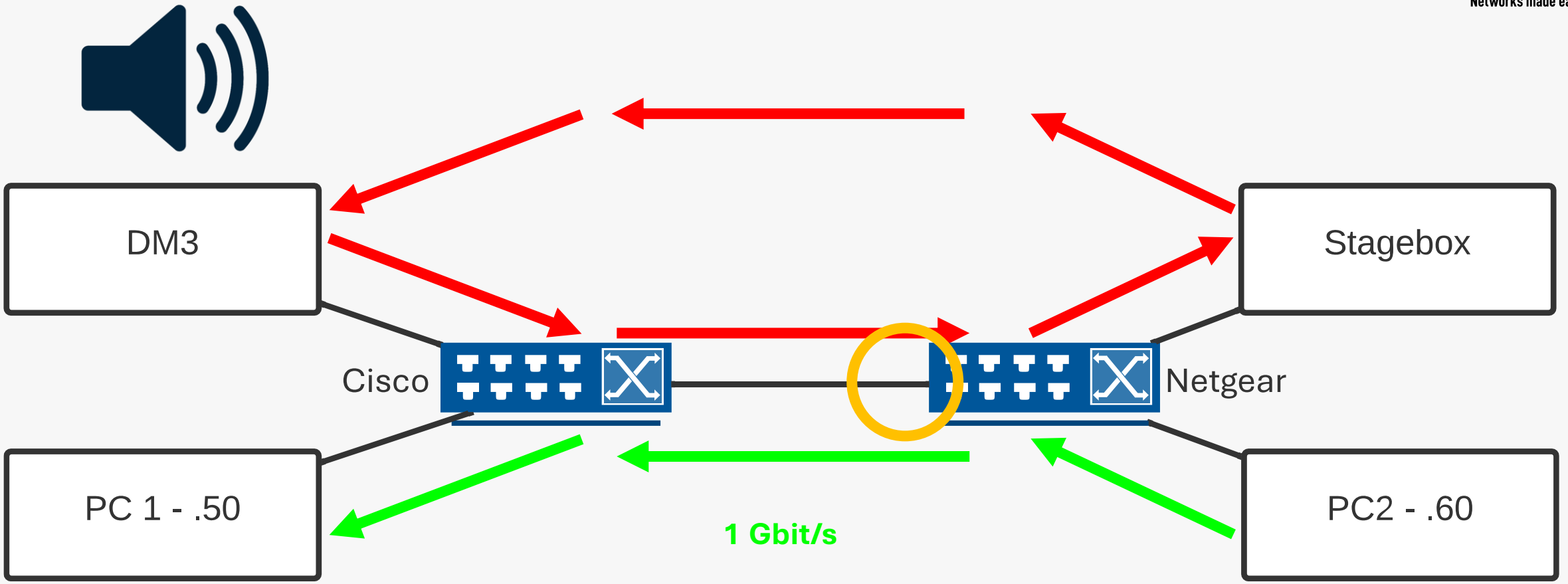
DSCP Wert den Queues zuordnen



DEMO: Tx Config

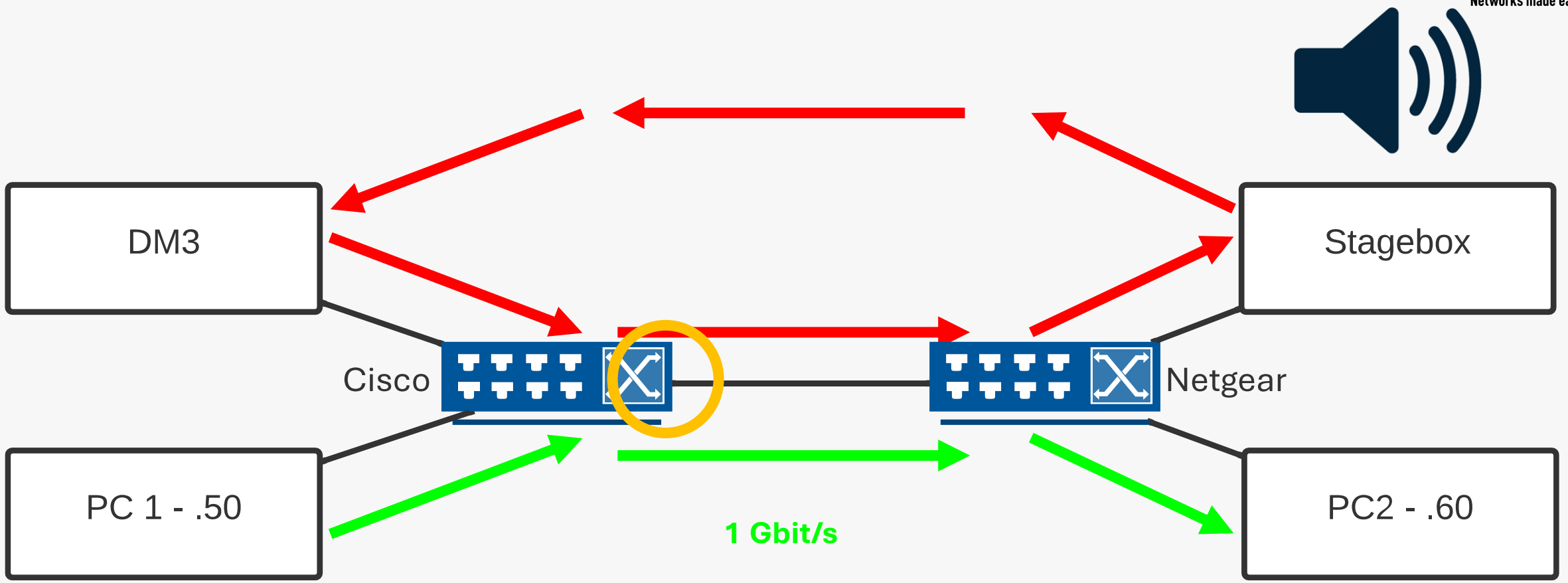
DEMO: Basic QoS Konfig für PTP auf Netgear

DSCP Wert von 56 auf High Priority



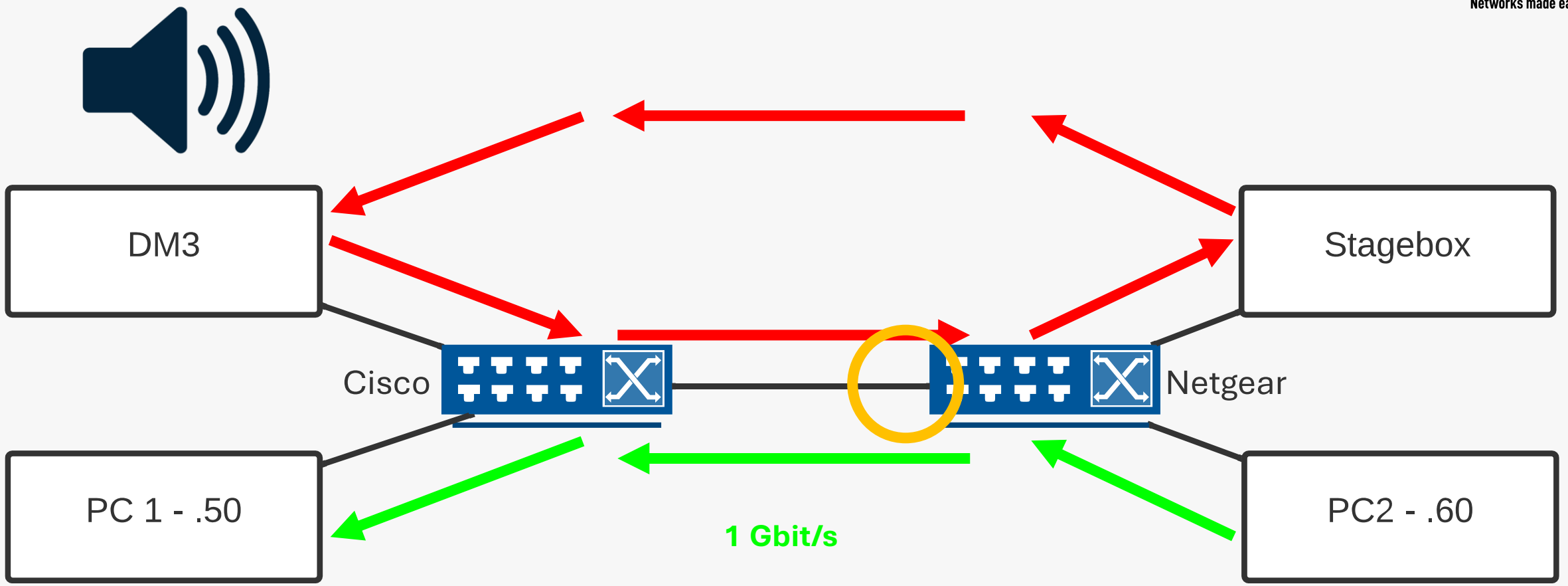
DEMO: Tx Config

DEMO: Basic QoS Konfig auf Cisco



DEMO: Tx Config

DEMO: Basic QoS Konfig auf Netgear



DEMO: Tx Config

DEMO: Advanced QoS Konfig

1 → 2 → 3

Class mit DSCP-Mapping für Traffic erstellen (mit einem Filter)

Class einer Policy zuordnen

Policy einem Port zuordnen

Netgear GS305E

Quality of Service	
Rate Limiting	Yes
DSCP	Yes
IEEE 802.1p COS	Yes
Port-based VLAN	Yes
TOS	Yes
WRR (Weighted Round Robin)	Yes
Strict Priority queue technology	Yes

Cisco CBS350

Quality of Service	
Priority levels	8 hardware queues
Scheduling	Strict priority and Weighted Round-Robin (WRR)
Class of service	Port based; 802.1p VLAN priority-based; IPv4/v6 IP precedence/Type of Service (ToS)/DSCP-based; Differentiated Services (DiffServ); classification and remarking ACLs, trusted QoS Queue assignment based on DSCP and class of service (802.1p/CoS)
Rate limiting	Ingress policer; egress shaping and rate control; per VLAN, per port, and flow based; 2R3C policing
Congestion avoidance	A TCP congestion avoidance algorithm is required to minimize and prevent global TCP loss synchronization

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Quality of Service (QoS) - Summary	
Access Lists	Yes
L2 MAC, L3 IP and L4 Port ACLs	Yes
Ingress	Yes
Egress	Yes
Time-based	Yes
802.3ad (LAG) for ACL assignment	Yes
Binding ACLs to VLANs	Yes
ACL Logging	Yes
Support for IPv6 fields	Yes

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DiffServ QoS	Yes
Edge Node applicability	Yes
Interior Node applicability	Yes
802.3ad (LAG) for service interface	Yes
Support for IPv6 fields	Yes
Ingress/Egress	Yes
IEEE 802.1p COS	Yes
802.3ad (LAG) for COS configuration	Yes
WRED (Weighted Deficit Round Robin)	Yes
Strict Priority queue technology	Yes
Single Rate Policing	Yes (CLI only)
Committed Information Rate	Yes
Committed Burst Size	Yes
Excessive Burst Size	Yes
DiffServ feature applied to class maps	Yes

Take Home Messages

1

Habe ich ein Bottleneck in meinem Netzwerk?

2

Welchen Traffic brauche ich unbedingt

3

Macht einen Stresstest

Leo Künne

Geschäftsführer der CX-Networks GmbH

Seit 2015 in der Branche