Understanding Bandwidth Profiles in MEF 6.2 Service Definitions

June 2015

Table of Contents

Table of Figures

1 Abstract

Bandwidth profiles used in MEF 6.2, *Ethernet Services Definitions – Phase 3*, have significantly changed compared to those used in MEF 6.1, *Ethernet Services Definitions – Phase 2*. The following items highlight some significant changes in MEF 6.2:

- The bandwidth profile algorithm is generalized to support more than one flow with token sharing (prioritized bandwidth sharing) among flows.
- Per-UNI and per-EVC bandwidth profiles are no longer used.[1]
- At egress, per-CoS ID bandwidth profiles are replaced by per-EEC ID bandwidth profiles.[2]

This paper explains MEF 6.2 bandwidth profiles in relation to MEF 6.1 bandwidth profiles. It discusses backward compatibility, explains expanded capabilities, and offers some insight into using them.

Note: *MEF 6.2 supersedes and replaces MEF 6.1.*

Readers are assumed to be familiar with MEF 10.2 bandwidth profiles used in MEF 6.1 services.

2 Background

2.1 MEF 6.1 Bandwidth Profiles

MEF 6.1 services use the six bandwidth profiles defined in MEF 10.2:

Ingress	Egress
Per-UNI ingress bandwidth profile	Per-UNI egress bandwidth profile
Per-EVC ingress bandwidth profile	Per-EVC egress bandwidth profile
Per-CoS ID ingress bandwidth profile	Per-CoS ID egress bandwidth profile

Each bandwidth profile is defined by six parameters (CIR, CBS, EIR, EBS, CF, and CM) that, together with the MEF 10.2 bandwidth profile algorithm, define bandwidth profile processing for a single unidirectional flow of service frames at a UNI.

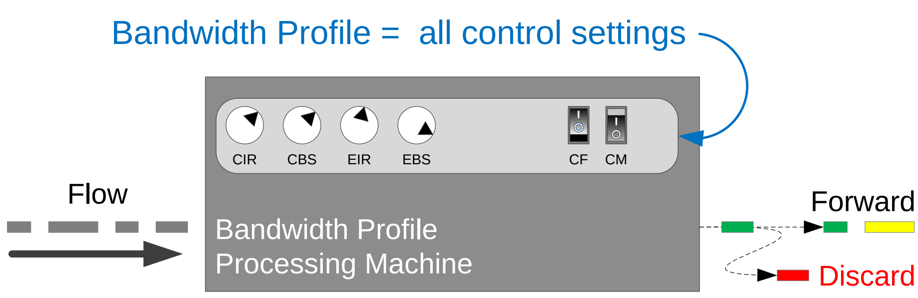

Figure 1: MEF 10.2 Bandwidth Profile Algorithm Visualized as Conceptual Machine

Conceptually, the MEF 10.2 bandwidth profile algorithm can be visualized as a user-configurable machine that processes a single flow of service frames. The machine (algorithm) is configured using four control dials (CIR, CBS, EIR, and EBS) and two switches (CM, CF) that are set to specific values (the bandwidth profile) as specified in the SLA. The bandwidth profile algorithm (machine) declares each service frame in the flow to be compliant or non-compliant relative to the bandwidth profile (machine control settings). The level of compliance is expressed as one of three colors:

- **Green** (CIR-conformant) – Service frames are in-profile with respect to service performance objectives and are forwarded.

[1] [R6] and [R8] in MEF 6.2 explicitly disallows per-UNI and per-EVC bandwidth profiles.
[2] Here, EEC refers to **Egress Equivalence Class**, a new definition for specifying egress service frame classification (similar to CoS).

- **Yellow** (EIR-conformant) – Service frames are out-of-profile with respect to service performance objectives, but are still forwarded (with discard-eligible status)
- **Red** (Non-conformant) – Service frames are out-of-profile and immediately discarded.

Bandwidth profiles are specified in SLAs to quantify agreed limits on service frame bandwidth and, as a consequence, they define traffic management operations within networks, such as policing, shaping and scheduling.

MEF 10.2 defines bandwidth profiles at three levels of flow granularity:

- **Per-UNI Bandwidth Profile**– Process all frames at a given UNI.
- **Per-EVC Bandwith Profile** – Process all frames in a given EVC (at a given UNI).
- **Per-CoS ID Bandwidth Profile** – Process all frames with a given CoS ID (in a given EVC at a given UNI).

Note: *The MEF 10.2 per-CoS ID bandwidth profile only processes frames from a single EVC.*

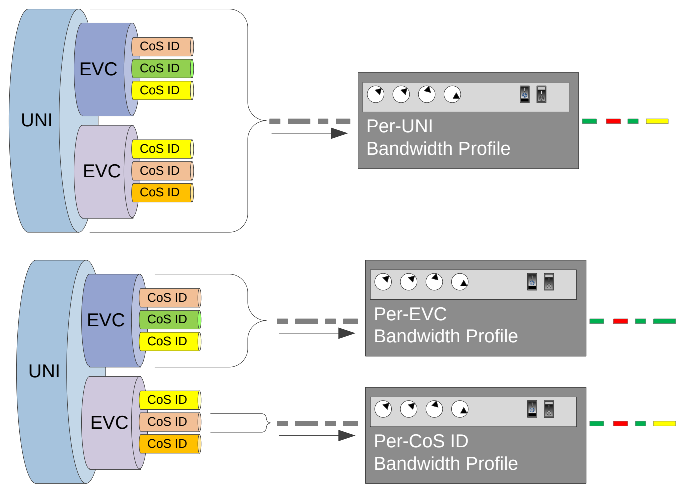

Figure 2: Three Levels of Bandwidth Profiles

2.2 MEF 10.3 Bandwidth Profiles

MEF 10.3 (which supersedes and replaces MEF 10.2) generalizes the bandwidth profile algorithm to process more than one flow and to allow token sharing (prioritized bandwidth sharing) among flows.

Conceptually, the MEF 10.3 bandwidth profile algorithm can be visualized as a user-configurable machine formed by a stack of user-configurable modules. Each module of this conceptual machine processes frames for one flow and is configured using six control dials (CIR^i, CIR^i_{max}, CBS^i, EIR^i, EIR^i_{max}, and EBS^i) and two switches (CF^i and CM^i). The machine also has one switch (CF^0) that is not part of any module. The set of all control settings, across all modules plus CF^0, is called the bandwidth profile.[3]

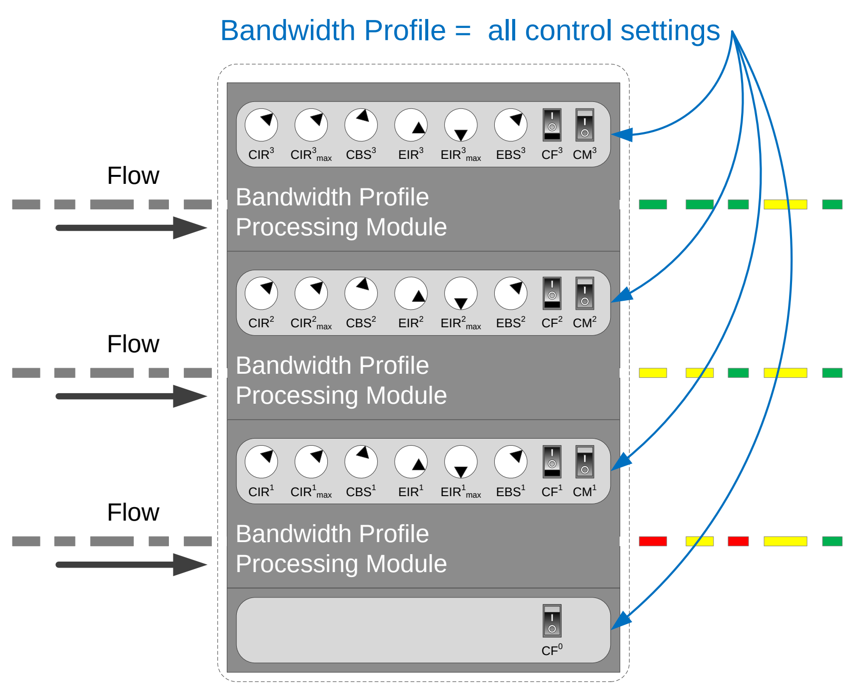

Figure 3: MEF 10.3 Bandwidth Profile Algorithm Visualized as Conceptual Machine

[3] The bandwidth profile also includes the ordering of flows within the stack, which is specified using another parameter (ER_i) that declares the flow's position, called rank or **Envelope Rank (ER)**, in the stack.

***Note**: Bandwidth profile parameters are indexed with superscripts. Do not confuse indexing with power notation. For example, CIR^3 denotes CIR for the third bandwidth profile flow, not CIR cubed.*

Token sharing (prioritized bandwidth sharing) occurs between modules within this machine (as described later in this paper).

Using this generalized algorithm, MEF 10.3 defines generalized (multi-flow) bandwidth profiles for five of the six bandwidth profiles defined in MEF 10.2:

	MEF 10.2 Bandwidth Profiles	MEF 10.3 Bandwidth Profiles
1.	Per-UNI ingress bandwidth profile	Per-UNI ingress bandwidth profile
2.	Per-EVC ingress bandwidth profile	Per-EVC ingress bandwidth profile
3.	Per-CoS ID ingress bandwidth profile	Per-CoS ID ingress bandwidth profile
4.	Per-UNI egress bandwidth profile	Per-UNI egress bandwidth profile
5.	Per-EVC egress bandwidth profile	Per-EVC egress bandwidth profile

The sixth MEF 10.2 bandwidth profile (the *per-CoS ID egress bandwidth profile)* is replaced in MEF 10.3 by a new bandwidth profile: the per-EEC ID egress bandwidth profile.

	MEF 10.2 Bandwidth Profiles	MEF 10.3 Bandwidth Profiles
6.	Per-CoS ID egress bandwidth profile	Per-EEC ID egress bandwidth profile

Here, EEC refers to **Egress Equivalence Class**, a new definition for specifying egress service frame classification, introduced in MEF 10.3. EEC ID is similar to CoS ID, but is independent of CoS ID, as described later in this paper.

Overall, the whole system of MEF 10.3 bandwidth profiles is backwardly compatible with the whole system of MEF 10.2 bandwidth profiles (any MEF 10.2 bandwidth profile can be translated to an equivalent MEF 10.3 bandwidth profile). However, MEF 6.2 does not adopt the entire system of MEF 10.3 bandwidth profiles, as explained in the next section.

2.3 MEF 6.2 Bandwidth Profiles

MEF 6.2 defines EVC services using only two out of the six MEF 10.3 bandwidth profiles[4] – the two most granular ones:

- Per-CoS ID ingress bandwidth profile
- Per-EEC ID egress bandwidth profile

The aforementioned differences in MEF 6.2 bandwidth profiles requires further explanation to understand how to relate them to MEF 6.1 bandwidth profiles. The MEF 6.2 algorithm is more general (it can support multiple flows with token sharing among flows), however per-UNI and per-EVC bandwidth profiles (used with MEF 6.1 service definitions) are not used with MEF 6.2 service definitions. Additionally, the per-CoS ID egress bandwidth profile is replaced by the per-EEC ID egress bandwidth profile.

[4] [R6] and [R8] in MEF 6.2 explicitly disallows per-UNI and per-EVC bandwidth profile attributes (even though both are defined in MEF 10.3).

2.4 Revised System for Service Frame Classification

In MEF 6.1 services, CoS classification is used for (up to) three purposes:

MEF 6.1 Classification	Purpose
CoS	Associate frame to a particular CoS Name, which determines it's QoS treatment in the CEN
	Associate frame to a particular per-CoS ID ingress bandwidth profile flow
	Associate frame to a particular per-CoS ID egress bandwidth profile flow

In MEF 6.2 services, service frame classification is enhanced with a second form of service frame classification (EEC classification) that is similar to CoS classification, but operates independently. In MEF 6.2 services, CoS classification continues to support the first two purposes, but the third purpose is reassigned to EEC classification:

MEF 6.2 Classification	Purpose
CoS	Associate frame to a particular CoS Name, which determines it's QoS treatment in the CEN
	Associate frame to a particular per-CoS ID ingress bandwidth profile flow
EEC	Associate frame to a particular per-EEC ID egress bandwidth profile flow

This logically separates CoS identification from egress bandwidth profile processing.

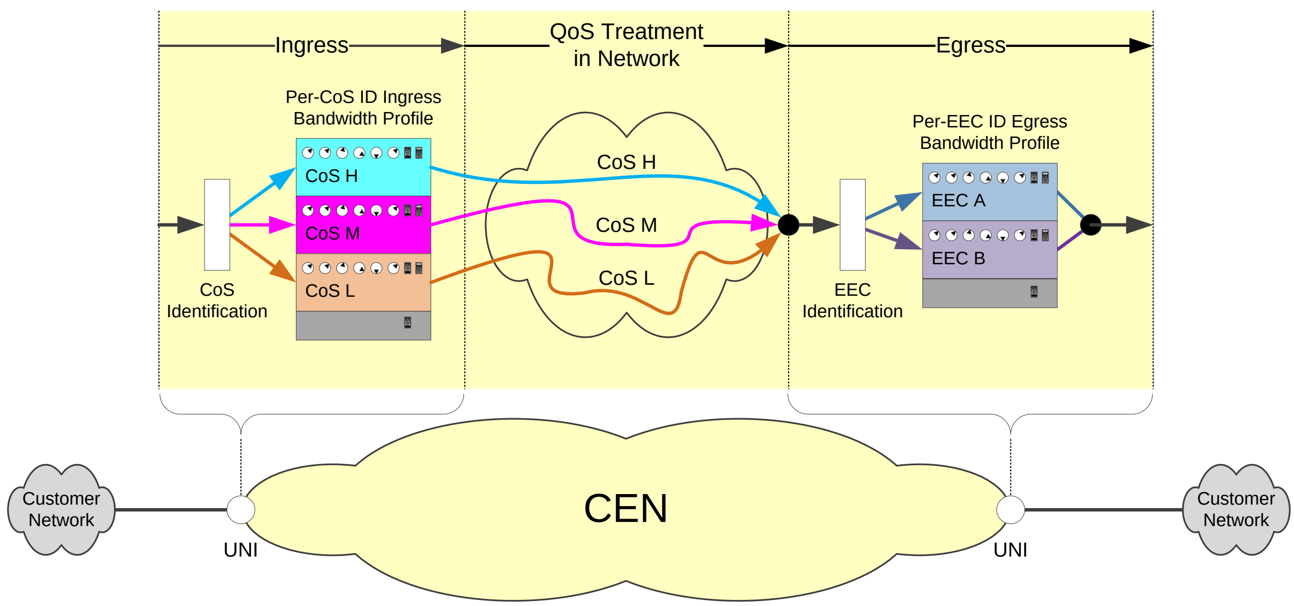

Figure 4: The Purposes of MEF 6.2 Service Frame Classification

Notice that when MEF 6.2 egress bandwidth profiles are used, frames may be classified twice during transport: once at ingress and (optionally) again at egress.

2.4.1 CoS Name Assignment

Per MEF 6.2, CoS Name is assigned to service frames at ingress as specified in the SLA using three EVC-per-UNI attributes:

- Class of Service Identifier for Data Service Frame
- Class of Service Identifier for L2CP Service Frame
- Class of Service Identifier for SOAM Service Frame

***Note**: MEF 6.1 service definitions do not include these attributes. They are new to MEF 6.2.*

Each of these attributes either specifies a single CoS Name (for all service frames of type Data, L2CP, or SOAM; per EVC at the UNI) or defines a system for assigning CoS Name based on service frame content, such as PCP bits, DSCP bits, or L2CP. CoS Name identification, in turn, assigns the frame to a particular ingress bandwidth profile flow and to a particular QoS treatment within the CEN.

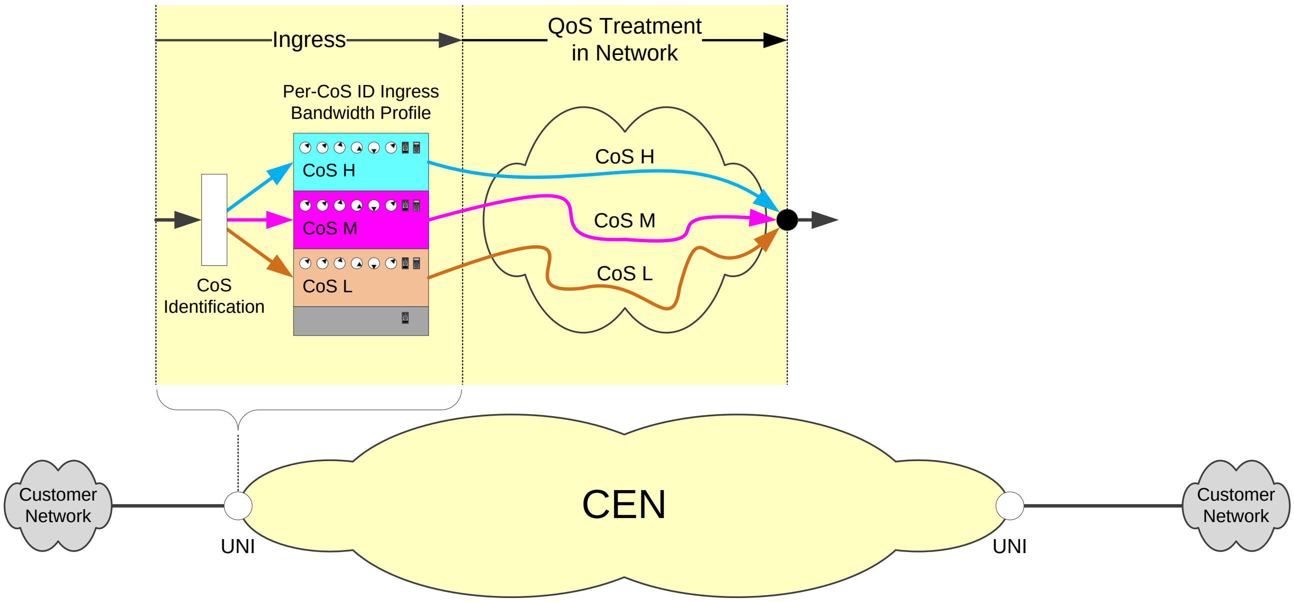

Figure 5: The Purpose of CoS Identification

2.4.2 EEC Assignment

EEC, if used, is assigned to service frames at egress as specified in the SLA using three EVC-per-UNI attributes:

- Egress Equivalence Class Identifier for Data Service Frames
- Egress Equivalence Class Identifier for L2CP Service Frames
- Egress Equivalence Class Identifier for SOAM Service Frames

Each of these attributes either specifies a single EEC ID (for all service frames of type Data, L2CP, or SOAM; per EVC at the UNI) or defines a system for assigning EEC ID based on service frame content, such as PCP bits, DSCP bits, or L2CP. EEC identification, in turn, assigns the service frame to a particular egress bandwidth profile flow.

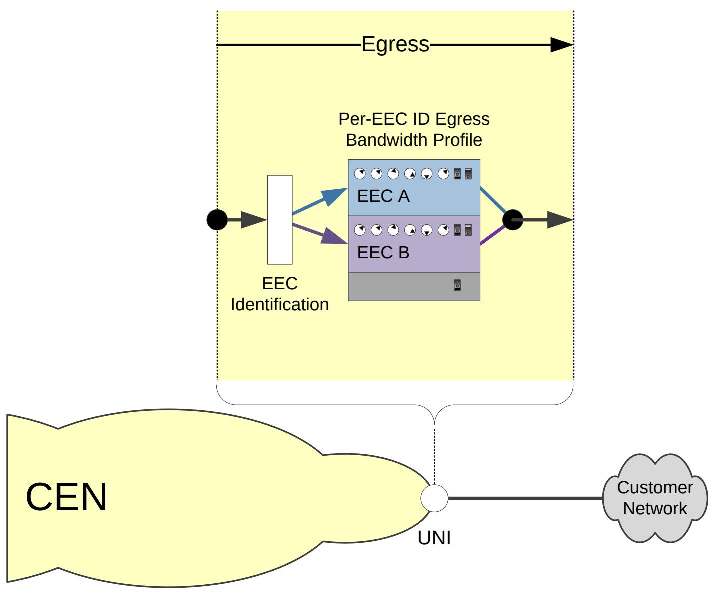

Figure 6: The Purpose of EEC Identification

3 Explaining MEF 6.2 Bandwidth Profiles

The MEF 10.3 bandwidth profile algorithm generalizes the MEF 10.2 bandwidth profile algorithm to support multiple flows with token sharing (prioritized bandwidth sharing) among flows.

Conceptually, the MEF 10.3 multi-flow algorithm can be modeled as a linked system of single-flow algorithms. Each module processes frames quasi-independently, using two token buckets in the familiar MEF

10.2 fashion. However, the overall algorithm includes new mechanisms that allow unused tokens to pass between modules (token sharing), so frame processing by each module is not truly independent.

The algorithm will be explained in steps, first ignoring token sharing, then adding and explaining token sharing mechanisms one-by-one.

3.1 Single-Flow Processing, Ignoring Token Sharing

Each flow^i (*i=1,…N*) is assigned to a dedicated module that processes the flow using two token buckets (one green and one yellow) using familiar rules adopted from the MEF 10.2 bandwidth profile algorithm:

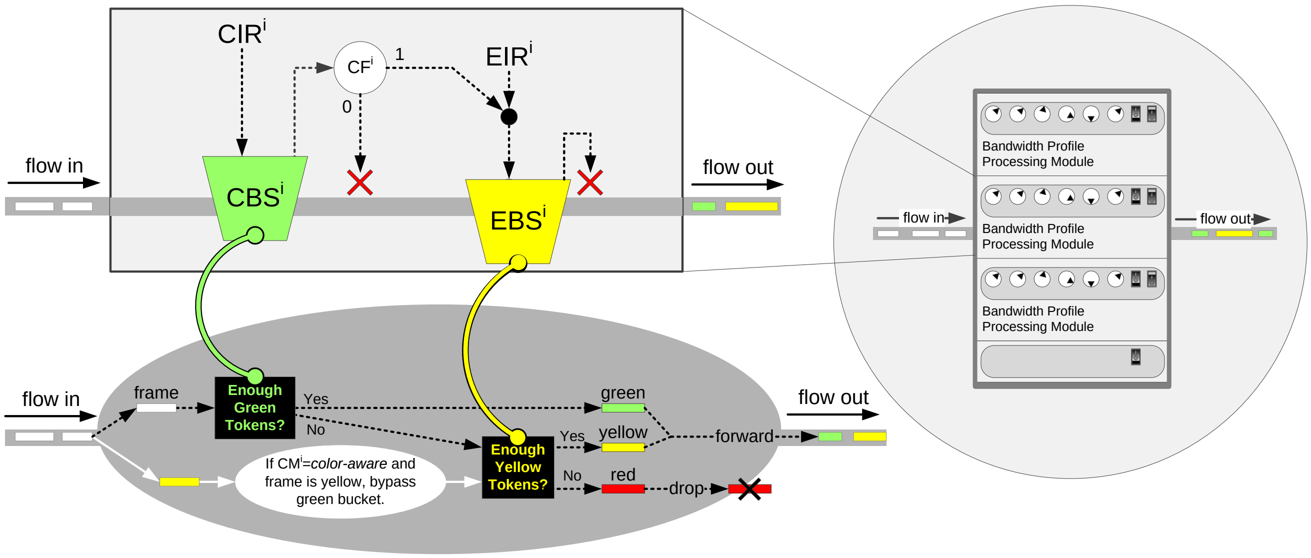

Figure 7: Single-Flow Processing, Ignoring Token Sharing

- To be assigned color green, the green bucket must contain *one token for each byte in the frame*. If green is assigned to the frame, *that* number of tokens is drained from the green token bucket.
- To be assigned color yellow, the yellow bucket must contain *one token for each byte in the frame*. If yellow is assigned to the frame, *that* number of tokens is drained from the yellow token bucket.
- Each frame is assigned one color: green (if possible), otherwise yellow (if possible), otherwise red.
- If parameter CM^i is set to *color-aware*, frames that are pre-colored yellow bypass green bucket processing and go directly to yellow bucket processing.
- Both buckets have a size (maximum token capacity) that is set by CBS^i (green bucket) or EBS^i (yellow bucket).
- Both buckets have a nominal token fill rate that is set by CIR^i/8 (green bucket) or EIR^i/8 (yellow bucket).
- If parameter CF^i is set to 1, tokens overflowing from the green bucket go into the yellow bucket.

All of this processing matches MEF 10.2 bandwidth profile processing. If the MEF 10.3 bandwidth profile includes only one flow, it is defined using only six parameters (CIR^i, CBS^i, EIR^i, EBS^i, CF^i, and CM^i) and becomes equivalent to the MEF 10.2 bandwidth profile.

3.2 Multi-Flow Processing with Token Sharing

The MEF 10.3 bandwidth profile algorithm adopts all of the aforementioned per-flow processing from the MEF 10.2 bandwidth profile algorithm, and then enhances it with new mechanisms to support token sharing between flows as explained incrementally in the following figures.

As a starting point, assume that each module processes frames independently, per the MEF 10.2 bandwidth profile algorithm. No tokens are shared between modules.

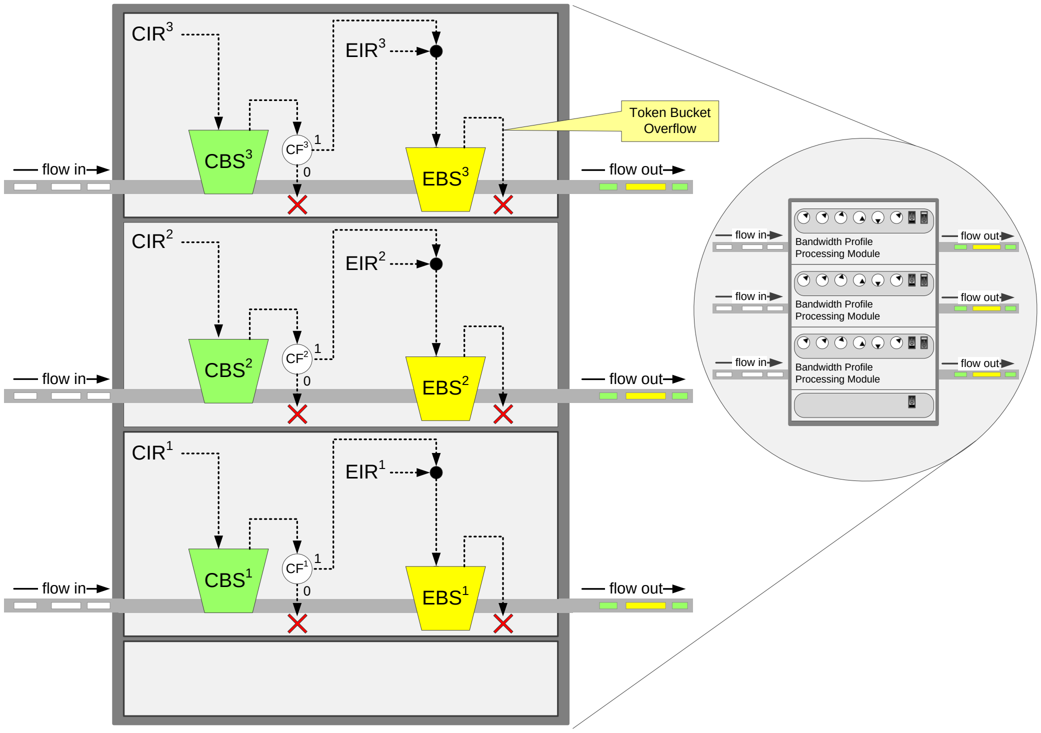

Figure 8: Independent Processing (per MEF 10.2)

Now add pathways to allow tokens (previously lost due to bucket overflow) to flow downward to the next module below.

Yellow bucket overflow now goes to the next yellow bucket. Green bucket overflow when CF^i=0 goes to the next green bucket.

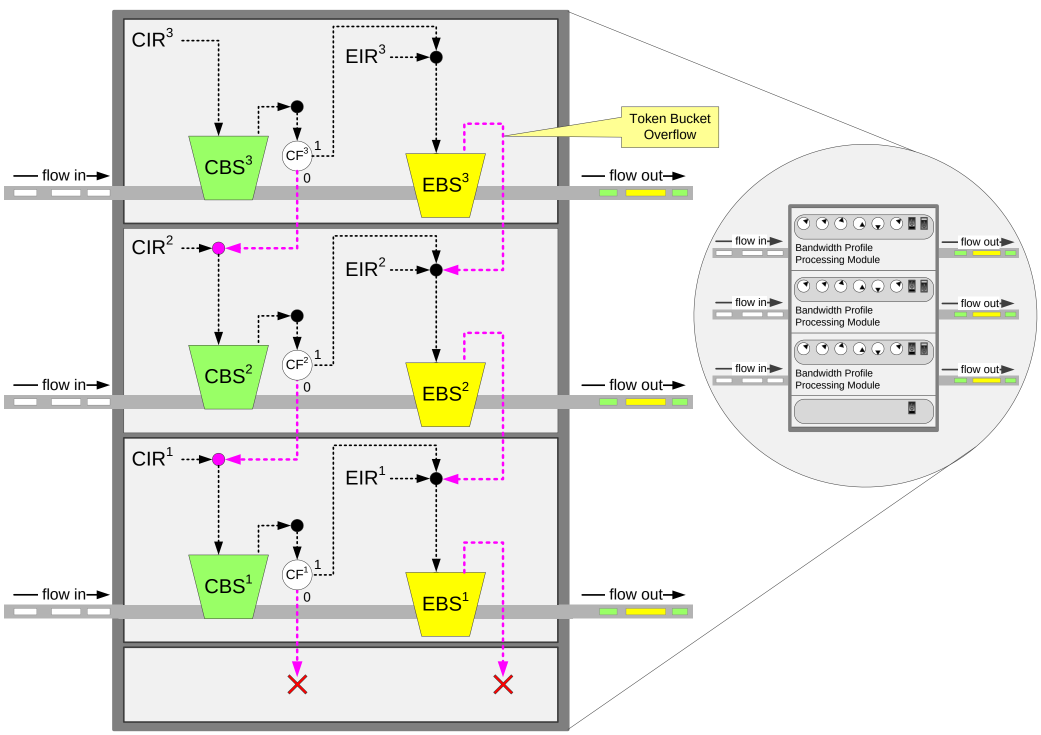

Figure 9: New Paths For Token Sharing

Now add a new rate limiting mechanism (shown graphically as a funnel) above each token bucket. Each of these mechanisms has one control setting, CIR^{i}_{max} (green bucket) or EIR^{i}_{max} (yellow bucket), which limits the rate of token flow into the token bucket.

The rate limiting mechanism does not store tokens or discard tokens. It functions like a gatekeeper that admits all tokens to the token bucket unless tokens arrive at a rate greater than the limit set (CIR^{i}_{max} or EIR^{i}_{max}). When tokens arrive faster than the limit (CIR^{i}_{max} or EIR^{i}_{max}), the rate limiter fills the token bucket at the limiting rate (CIR^{i}_{max} or EIR^{i}_{max}) and passes remaining tokens onward, to be combined with tokens from token bucket overflow.

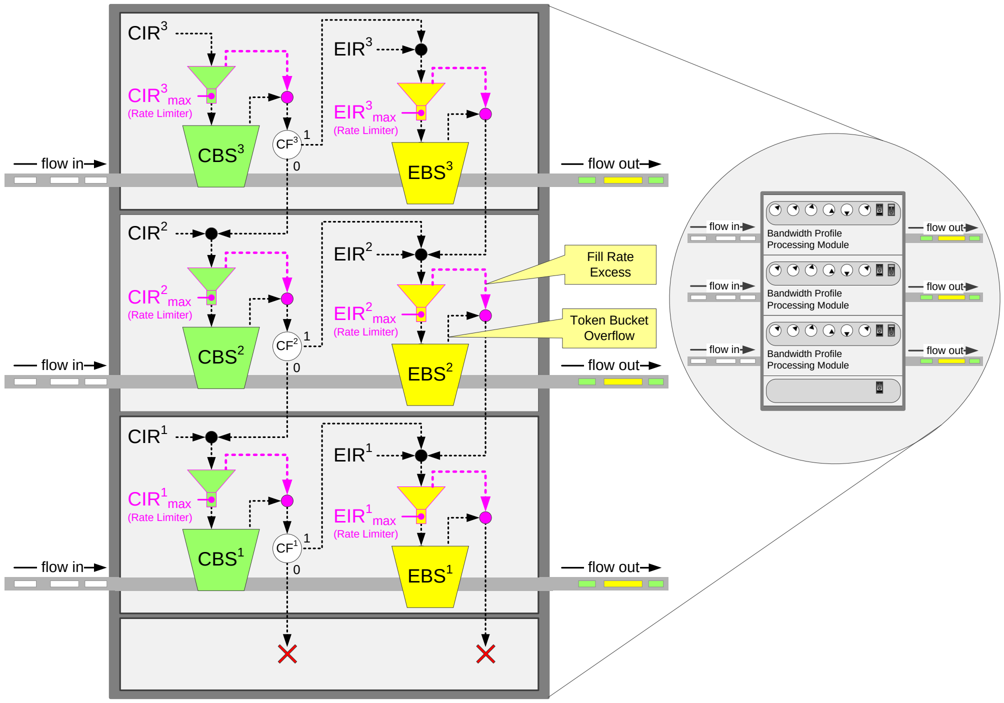

Figure 10: New Rate Limiters

Notice that all modules, except the bottom one, preserve unused tokens (representing available bandwidth) by passing them downward for possible use by lower ranking flows.

3.2.1 $CF^0=0$

If the system-wide coupling flag (CF^0) is set to zero ($CF^0=0$), the algorithm operates as previously described.

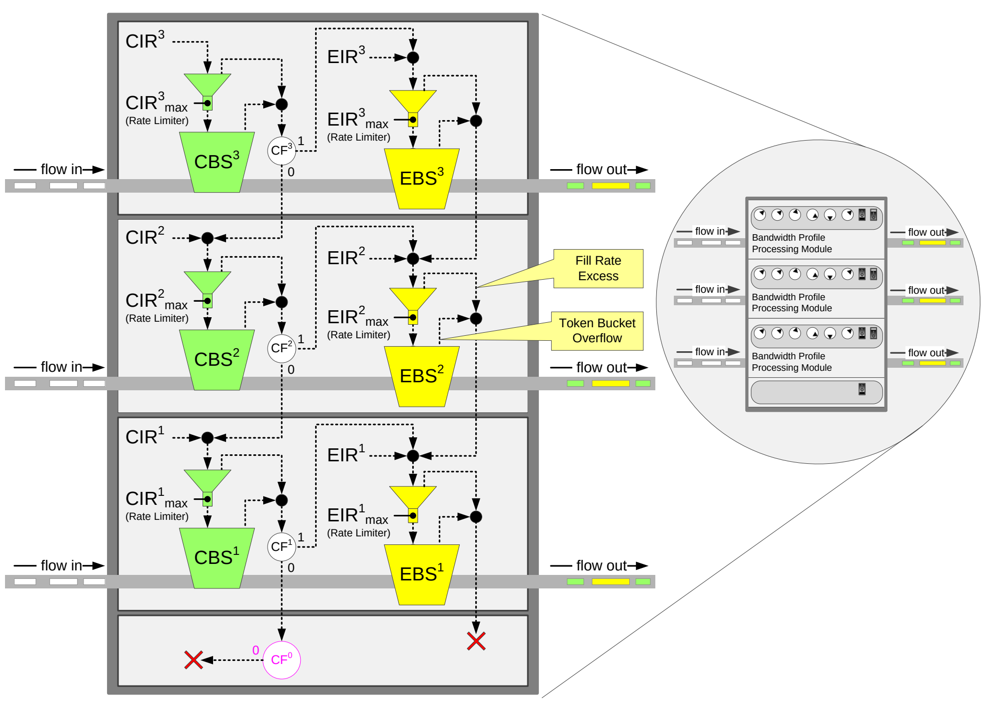

Figure 11: Bandwidth Profile with $CF^0=0$

3.2.2 CF^0=1

Otherwise (if CF^0=1), there are two changes: (1) tokens overflowing from the bottom green bucket flow upward to the top yellow bucket and (2) all of the other coupling flags are set to zero[5].

Notice that CF^0=1 forces all the other CF flags to have the value 0, defining the path for token sharing. Unused tokens pass through the chain of green buckets (top to bottom), then through the chain of yellow buckets (top to bottom).

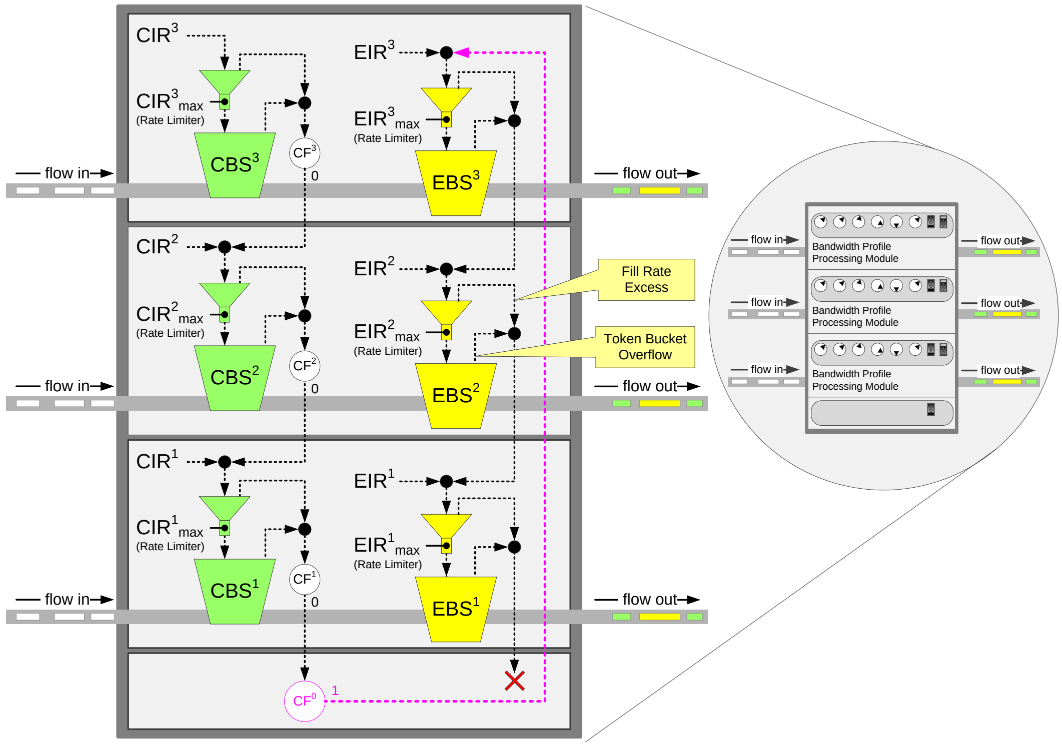

Figure 12: Bandwidth Profile with CF^0=1

The key feature differentiating the MEF 10.3 bandwidth profile algorithm (used by MEF 6.2 services) from the MEF 10.2 bandwidth profile algorithm (used by MEF 6.1 services) is the ability to govern more than one flow with bandwidth shared among flows in a flexible and explicitly-defined manner.

The system for sharing bandwidth is flexible, but is not without structure:

- Tokens from a green bucket cannot overflow to higher ranking green bucket
- Tokens from a yellow bucket cannot overflow to higher ranking yellow bucket
- Tokens from a yellow bucket cannot overflow to green bucket

Unused tokens (bandwidth) are only shared from higher-ranking flows to lower-ranking flows or with color demotion from green to yellow.

This implies that flows should be ordered (ranked) such that unused bandwidth is downwardly shareable. For example, higher CoS flows are typically ranked higher than lower CoS flows because unused bandwidth from a higher CoS flow can usually be reallocated to a lower CoS flow without increasing service performance commitment.

Note: *All flows processed by a MEF 10.3 bandwidth profile must be of the same type. For example, a MEF 6.2 bandwidth profile can be assigned to process multiple per-CoS ingress flows or multiple per-EEC egress flows, but not a combination of per-CoS ingress flows and per-EEC egress flows.*

[5] Per [R150] in MEF 10.3: If CF^0 = 1 for an envelope, then CF^i MUST equal 0 for all bandwidth profile flows mapped to the envelope.

3.3 New Terminology and Service Attributes

MEF 6.2 bandwidth profiles are defined using new terminology (*bandwidth profile flow*, *envelope*, and *rank*) and new service attributes (*Envelopes* and *Token Share*, *Ingress Bandwidth Profile per-CoS ID*, and *Egress Bandwidth Profile per-EEC ID*). Refer to the appendix of this paper for more details.

3.4 The Impact of Discontinuing Per-UNI and Per-EVC Bandwidth Profiles

Going from MEF 6.1 services to MEF 6.2 services, per-UNI and per-EVC bandwidth profile attributes are no longer used. MEF 6.2 bandwidth profiles must be per-CoS ID (at ingress) or per-EEC ID (at egress). However, there is no loss in functionality because a single MEF 6.2 bandwidth profile can process any number of flows, including all of the per-CoS ID flows (or per-EEC ID flows) at a UNI or EVC if desired.

A MEF 6.1 per-UNI (or per-EVC) bandwidth profile processes all frames at the UNI (or EVC) with no awareness of CoS ID. If the UNI (or EVC) supports multiple CoS ID flows, frames are processed indiscriminately (without awareness of CoS ID).

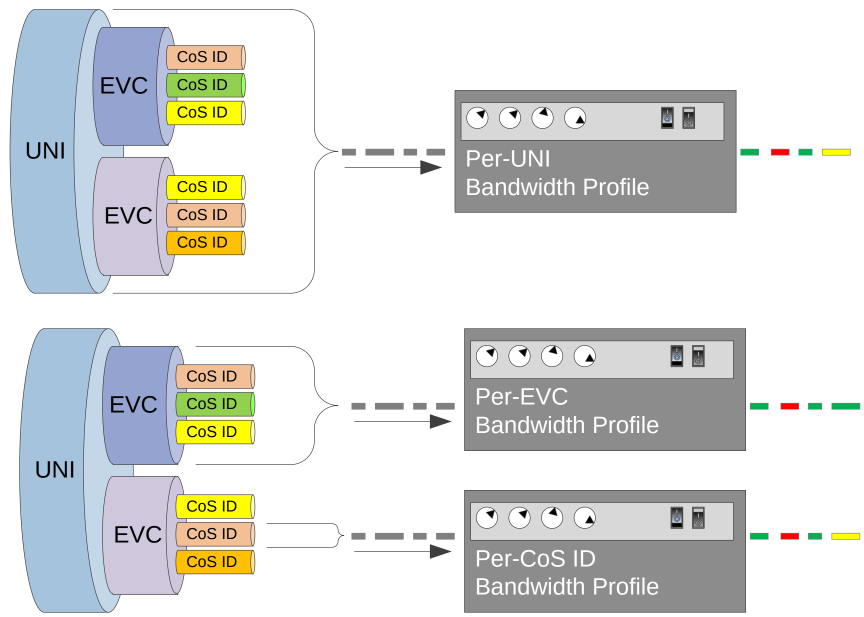

Figure 13: MEF 6.1 Per-UNI, Per-EVC and Per-CoS ID Bandwidth Profiles

A MEF 6.2 bandwidth profile can similarly process all frames at a UNI (or EVC). However, frame processing is no longer indiscriminate. The MEF 6.2 bandwidth profile explicitly defines how bandwidth is allocated per-CoS ID flow (or EEC ID flow) and how bandwidth is shared among flows.

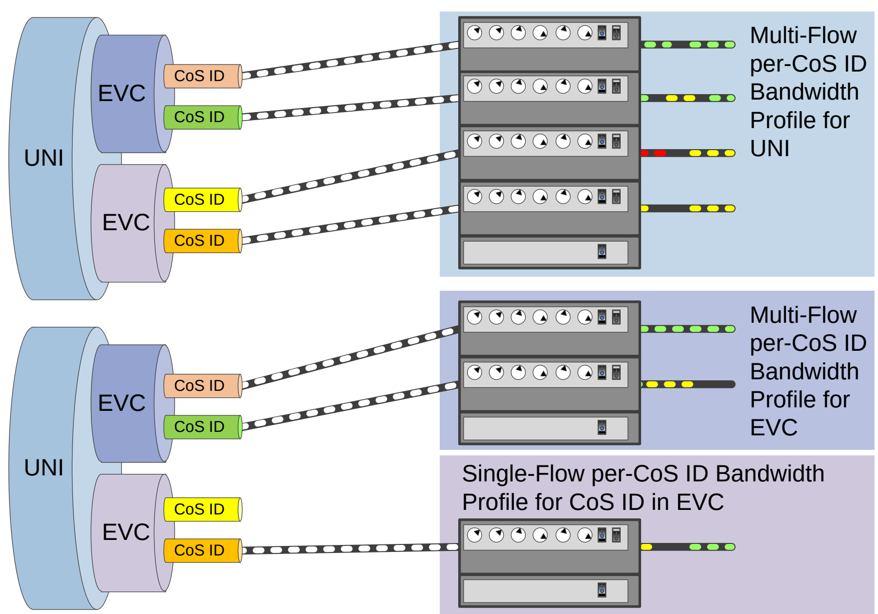

Figure 14: MEF 6.2 Bandwidth Profiles Applied per-UNI, per EVC and per-CoS ID in EVC

One might argue that MEF 6.2 bandwidth profiles are not fully backwardly compatible with MEF 6.1 bandwidth profiles because they do not permit "indiscriminate" per-UNI and per-EVC frame processing. However, MEF 6.2 bandwidth profiles include better (more flexible and less arbitrary) frame processing. So any loss of backward compatibility is actually beneficial.

3.5 New Opportunities for Sharing Bandwidth

The benefit of MEF 6.2 bandwidth profiles, compared to MEF 6.1 bandwidth profiles, is that they enable multiple flows to share a common pool of bandwidth in a flexible, prioritized, and well-defined fashion.

MEF 6.1 per-UNI and per-EVC bandwidth profiles allow multiple per-CoS ID flows. However, they lack any ability to prioritize how bandwidth is shared among those per-CoS flows. Such indiscriminate bandwidth sharing is not very useful to the subscriber because all traffic gets equal/random access to the available bandwidth, regardless of CoS ID.

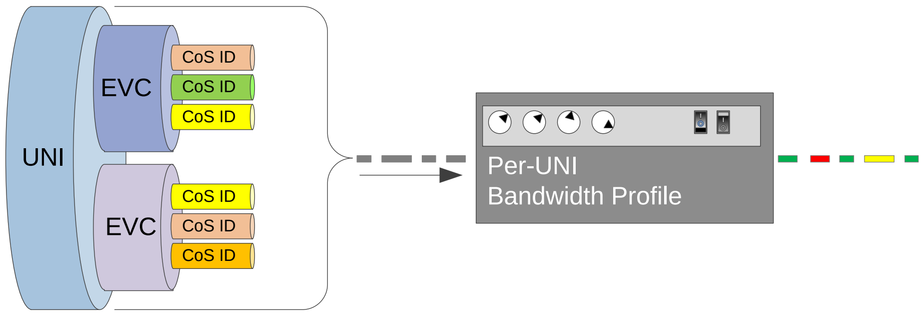

Figure 15: MEF 6.1 Per-UNI Bandwidth Profile

MEF 6.2 bandwidth profiles, in contrast, can include any selection of per-CoS ID flows (or per-EEC ID flows) from the set of all per-CoS ID flows (or per-EEC ID flows) present at the UNI.[6] The following example illustrates a UNI served by two per-CoS ID ingress bandwidth profiles:

- A multi-flow bandwidth profile that governs three per-CoS ID flows from two different EVCs
- A single-flow bandwidth profile that governs one per-CoS ID flow

All bandwidth associated with the single-flow bandwidth profile is dedicated to the single flow and cannot be shared with other flows. Any bandwidth that is unused by that flow is wasted. In contrast, the multi-flow bandwidth profile can allocate bandwidth to each of three flows and additionally allow unused bandwidth from higher ranking flows to "trickle down" to lower ranking flows. This benefits subscribers because it enables them to use all of the subscribed bandwidth.

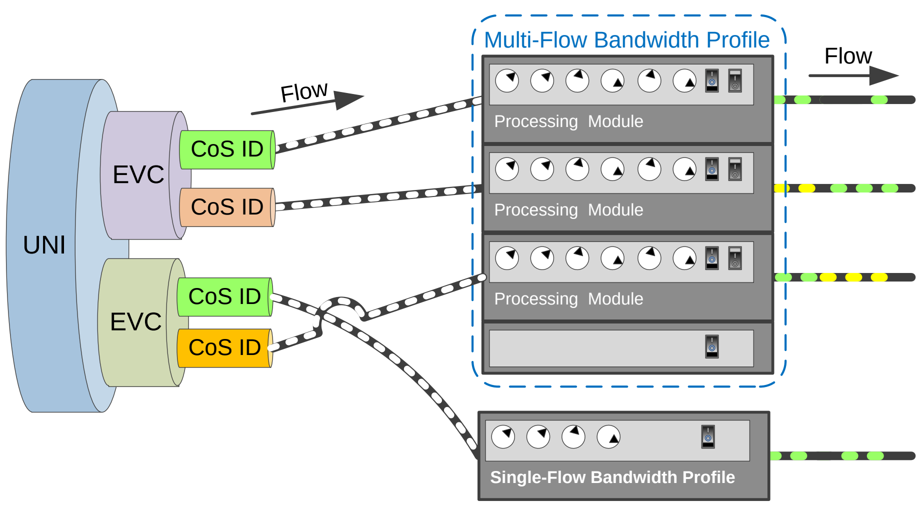

Figure 16: MEF 6.2 Per-CoS ID Ingress Bandwidth Profiles

[6] A bandwidth profile cannot include both per-CoS ID flows and per-EEC ID flows.

4 Using MEF 6.2 Bandwidth Profiles

Conceptually, at a high level, any bandwidth profile (MEF 6.1 or MEF 6.2) establishes two things:

- An agreed algorithm for processing frames at a particular external interface in the network[7] into three categories (green, yellow, and red)
- Limits on the quantity of green traffic and yellow traffic that will be supported for the service

Bandwidth profiles limit the quantity of ingress and egress traffic so that the service provider allocates sufficient network resources to ensure that green traffic is supported with agreed performance assurances specified in an SLA.

4.1 Using Ingress Bandwidth Profiles

At ingress, each service frame maps to a CoS Name which, in turn, assigns the frame to a particular ingress bandwidth profile flow and to particular QoS treatment within the CEN.

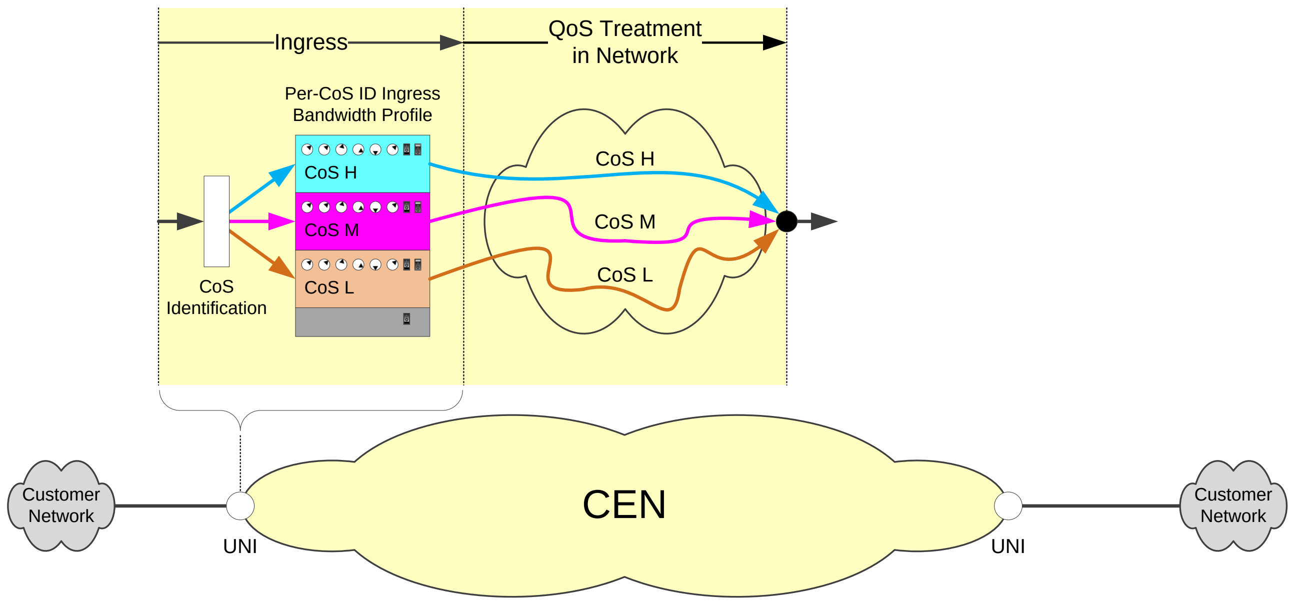

Figure 17: Ingress Bandwidth Profile Processing

The service provider typically uses the ingress bandwidth profile to condition traffic at ingress. Traffic conditioning includes policing which limits ingress traffic to agreed levels (per-CoS) and marking which assigns color (green or yellow) to those frames that are admitted.

The subscriber transmits service frames into the network (EVC) with full understanding of associated service delivery assurances as specified in the SLA. Green service frames are *in-profile* and provided with service performance objectives, while yellow frames are out of profile and not subject to any service performance objectives.

[7] In EVC services, bandwidth profiles apply at UNIs. In OVC services they can apply at UNIs and/or at ENNIs.

4.2 Using Egress Bandwidth Profiles

Egress bandwidth profiles are not allowed, nor required, for EPL services because there is no service multiplexing and thus no opportunity for traffic contention. However, they can be used with other MEF services as illustrated in the following examples.

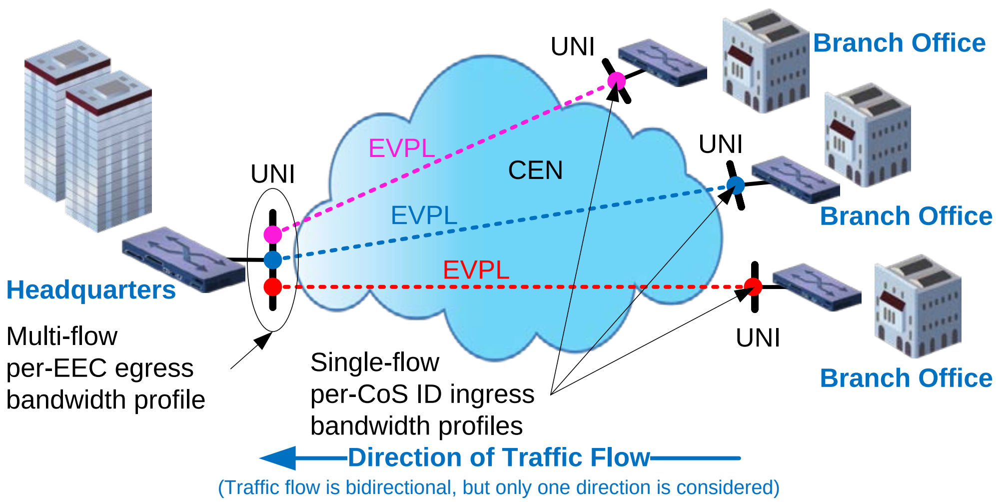

Figure 18: Example Use Case for Egress Bandwidth Profile with EVPLs

In this example, EVPLs from three branch offices are service multiplexed to one UNI at the company headquarters. Ingress bandwidth profiles applied at the branch offices already limit egress traffic aggregating to the company headquarters. However, the worst-case aggregate total may be more than the headquarters UNI can support or may cost more than the subscriber wishes to pay. This example illustrates the utility of egress bandwidth profiles. In this example, the egress bandwidth profile limits egress traffic at the headquarters UNI to the amount that the organization ordered (an amount that is less than the sum of all bandwidth that the three branch offices could send to the headquarters).

Egress bandwidth profiles serve this same purpose in multipoint service applications, such as in the following.

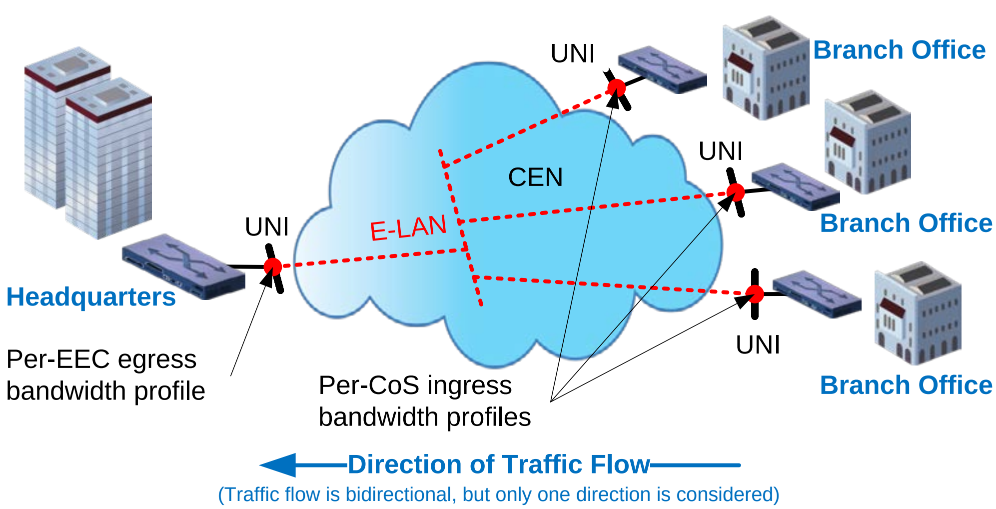

Figure 19: Example Use Case for Egress Bandwidth Profile with E-LAN

Without the egress bandwidth profile, the headquarters UNI would have to support the worst-case scenario where traffic from all of the branch office UNIs (limited only by the ingress bandwidth profiles) is sent to the headquarters UNI.

4.3 EEC ID and CoS ID

At egress, each service frame that maps to an EEC ID is assigned to a particular egress bandwidth profile flow. Egress bandwidth profile processing then determines the service frame's fate (whether it is discarded or delivered).

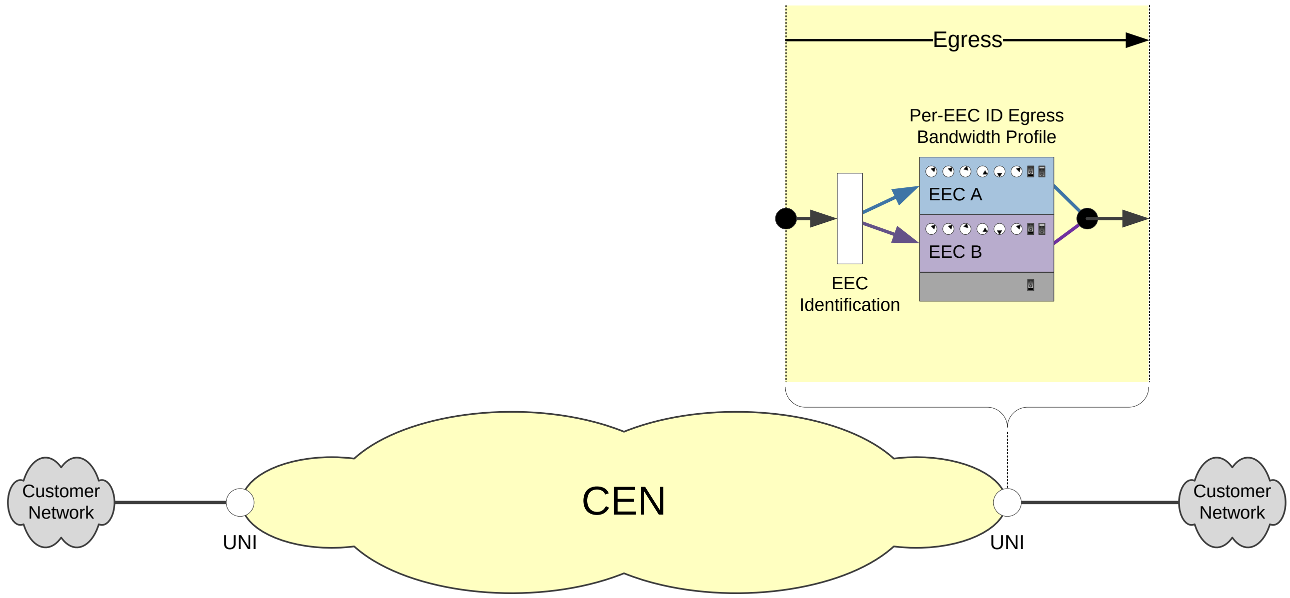

Figure 20: Egress Bandwidth Profile Processing

The following example illustrates CoS ID assignment and EEC ID assignment for a single service frame traveling from ingress UNI to egress UNI(s) in a multipoint service application.

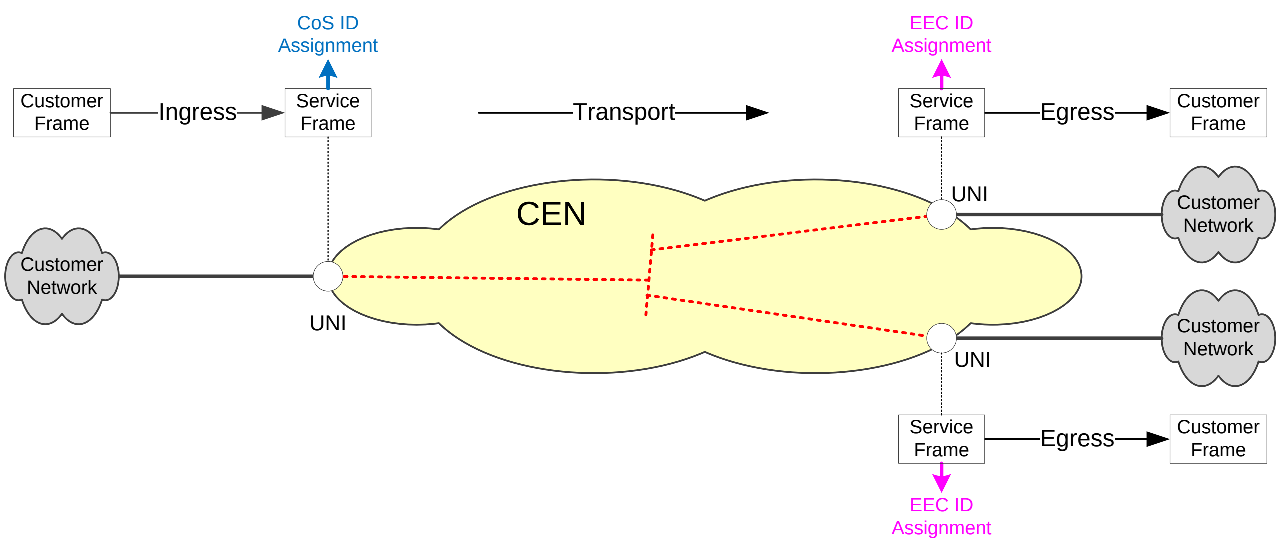

Figure 21: CoS ID and EEC ID Assignment

CoS ID assignment occurs at ingress. EEC ID assignment occurs at egress. Both may be different for different UNIs. Both can be assigned per-EVC (at the UNI) or based on service frame content (PCP or DSCP values) at the UNI. CoS ID assignment is independent of EEC ID assignment.

5 Summary

The MEF 6.2 update to EVC service definitions includes significant changes to bandwidth profiles:

- The MEF 10.2 bandwidth profile algorithm is replaced by a more general algorithm, defined in MEF 10.3, which can support multiple flows with an ability to share bandwidth among flows.
- Per-UNI and per-EVC bandwidth profiles (available in MEF 6.1 service definitions) are no longer used.
- At egress, the per-CoS ID bandwidth profile is replaced by the per-EEC ID egress bandwidth profile.

This paper has described and explained these changes at a conceptual level. MEF 6.2 and MEF 10.3 [3] provide normative requirements. Appendix C of MEF 10.3 provides informative bandwidth profile examples.

These new bandwidth profile capabilities enable service providers to differentiate their service offerings. Service providers and subscribers also benefit by obtaining more efficient bandwidth utilization through well-defined, flexible and prioritized bandwidth sharing among different flows.

6 Appendix: New Terminology

Term	Description
Bandwidth Profile Flow	The unidirectional flow of service frames processed by one "module" of the MEF 10.3 bandwidth profile algorithm is called a **bandwidth profile flow**. ***[R137], MEF 10.3****: A service frame must be mapped to at most one bandwidth profile flow.*
Envelope	The collection of bandwidth profile flows processed by a particular MEF 10.3 bandwidth profile is called an **envelope**. ***[R136], MEF 10.3****: Each bandwidth profile flow at a UNI must belong to exactly one envelope.*
Rank	Within an envelope, each bandwidth profile flow is assigned a unique **rank** between *1* (lowest) and *n* (highest) that determines the "module" that it is processed by. The flow assigned rank 1 is processed by the bottom "module". ***[R153], MEF 10.3****: The value of the rank [assigned to a bandwidth profile flow] must not equal the rank of any of the other bandwidth profile flows [within the same envelope]*

7 Appendix: New EVC Service Attributes

Attribute (Attribute Type)	Description
Envelopes (per-UNI)	Per MEF 6.2, attribute **Envelopes** specifies three values for each envelope that includes two or more bandwidth profile flows: • Envelope ID • CF^0 (value of the envelope-wide coupling flag) • n (the number of bandwidth profile flows in the envelope) ***[R5], MEF 6.2****: [The Envelopes attribute] must consist of only those envelopes with two or more bandwidth profile flows.* The Envelopes attribute does not account for envelopes that have just one bandwidth profile flow because single-flow bandwidth profiles are defined without Envelope ID or the other two values, which are known (CF^0=0, n=1).[8]

[8] Per [R142] in MEF 10.3, When one bandwidth profile flow is mapped to an envelope, CF^0 must equal 0.

Attribute (Attribute Type)	Description
Token Share (per-UNI)	Per MEF 6.2, attribute **Token Share** indicates whether or not the UNI is capable of sharing tokens across bandwidth profile flows. ***[R2], MEF 6.2****: A UNI, with Token Share enabled, must be able to support two or more bandwidth profile flows in at least one envelope.* ***[R3], MEF 6.2****: A UNI with Token Share disabled must have exactly one bandwidth profile flow per envelope.* If Token Share is disabled, the **Envelopes** per-UNI attribute will be an empty list, per [R5] in MEF 6.2.
Ingress Bandwidth Profile per-CoS ID (EVC-per-UNI)	Per MEF 10.3, attribute **Ingress Bandwidth Profile per-CoS ID** is assigned one of two values: ***No*** or ***Parameters***. If value *Parameters* is assigned, one of two sets of values must be specified for each CoS in the EVC that is assigned to the bandwidth profile.[9] If its envelope is not shared, seven values must be specified: CoS Name (for flow^i), CIR^i, CBS^i, EIR^i, EBS^i, CF^i, and CM^i Otherwise (if its envelope is shared), eleven values must be specified: CoS Name (for flow^i), CIR^i, CIR^i_{max} , CBS^i, EIR^i, EIR^i_{max}, EBS^i, CF^i, CM^i, and ER^i, where ER^i= <Envelope ID, rank>
Egress Bandwidth Profile per-EEC ID (EVC-per-UNI)	Per MEF 10.3, attribute **Egress Bandwidth Profile per EEC ID** is assigned one of two values: ***No*** or ***Parameters***. If value *Parameters* is assigned, one of two sets of values must be specified for each EEC in the EVC that is assigned to a bandwidth profile.[10] If its envelope is not shared, seven values must be specified: CoS Name (for flow^i), CIR^i, CBS^i, EIR^i, EBS^i, CF^i, and CM^i Otherwise (if its envelope is shared), eleven values must be specified: CoS Name (for flow^i), CIR^i, CIR^i_{max} , CBS^i, EIR^i, EIR^i_{max}, EBS^i, CF^i, CM^i, and ER^i, where ER^i= <Envelope ID, rank>

8 Glossary

Term	Description	Term	Description
Bandwidth Profile	A characterization of the lengths and arrival times for Service Frames at a reference point.	ENNI	External Network-to-Network Interface
Bandwidth Profile Flow	A set of Service Frames at a UNI that meet a specific set of criteria.	Envelope	A set of n Bandwidth Profile Flows in which each Bandwidth Profile Flow is assigned a unique rank between 1 (lowest) and n (highest).
CBS	Committed Burst Size	EPL	Ethernet Private Line
CE	Customer Edge	EVC	Ethernet Virtual Connection
CEN	Carrier Ethernet Network	EVPL	Ethernet Virtual Private Line

[9] Ingress service frames that are not assigned to a bandwidth profile flow are not subject to a bandwidth profile.
[10] Egress service frames that are not assigned to a bandwidth profile flow are not subject to a bandwidth profile.

Term	Description	Term	Description
CF	Coupling Flag	Ingress Service Frame	A Service Frame sent from the CE into the Service Provider network.
CIR	Committed Information Rate	L2CP Service Frame	Layer 2 Control Protocol Service Frame
CM	Color Mode	OAM	Operations, Administration, and Management
CoS	Class of Service	OVC	Operator Virtual Connection
CoS ID	Class of Service Identifier	PCP	Priority Code Point
CoS Name	A parameter used in Performance Metrics that specifies the Class of Service Name for the metric	QoS	Quality of Service
Data Service Frame	A Service Frame that is neither a Layer 2 Control Protocol Service Frame nor a SOAM Service Frame.	Service Frame	An Ethernet frame transmitted across the UNI in either direction
DSCP	Differentiated Services Code Point	Service Provider	The seller of network services
Egress Service Frame	A Service Frame sent from the Service Provider network to the CE.	SOAM	Service OAM
EBS	Excess Burst Size	SLA	Service Level Agreement
EEC	Egress Equivalence Class	SOAM service frame	A Service Frame that is not an L2CP Service Frame and whose Ethertype = 0x8902.
EEC ID	Egress Equivalence Class Identifier	Subscriber	The buyer of network services
EIR	Excess Information Rate	UNI	User-to-Network Interface
E-LAN Service Type	An Ethernet Service Type that is based on a Multipoint-to-Multipoint EVC		

9 References

[1] MEF 6.2, EVC Ethernet Service Definitions Phase 3, August, 2014.
[2] MEF 6.1, Ethernet Services Definitions - Phase 2, April, 2008.
[3] MEF 10.2, Ethernet Services Attributes Phase 2, October 2009.
[4] MEF 10.3, Ethernet Services Attributes Phase 3, October 2013.

10 Acknowledgements

Authors and Editors: Jon Kieffer and Ralph Santitoro, Fujitsu
Contributors: Bruce Eldridge, CenturyLink; Bruno Giguère, MEF, Yoav Cohen, RAD; Rami Yaron, Telco Systems.