Executive Summary

The 3GPP standards specifications are important guidelines that ensure efficiency across the industry. But vendors have always had to build additional, proprietary product features over the framework of the 3GPP standards to fully implement solutions. Standards were never intended to fully specify all functionality but instead serve mainly to ease multi-vendor interoperability.

Release 11 3GPP specifications recognized the importance of Layer-7 traffic identification for traffic management with the introduction of the Traffic Detection Function (TDF) and Sd reference point. For release 12, Sandvine was instrumental in championing the needs of service providers by bringing charging functions to the TDF, better acknowledging today’s service creation opportunities and challenges. The TDF and Sd reference point are important steps towards aligning standards with the needs and baseline functions of present day network policy control. These latest standards have significantly closed the gap on what the industry refers to as “standards-lag”.

However it is the overall architectural approach (e.g., embedded vs. standalone, freeform policy vs. rigid-form, etc.) and the implementation of features (e.g., on-wire PCRF functions) built on the framework of the 3GPP standards that make use cases possible and differentiate one network policy control vendor from another. This paper examines this reality in light of the 3GPP release 12 TDF and Sd reference point, demonstrating the difference between complying with the latest communication reference point and actually implementing important use cases.
Introduction

For several years Internet bandwidth data consumption has been dominated by over-the-top (OTT) applications\(^1\), and for years the 3GPP standards, conceived when traffic composition and the operational environment were very different, have lagged in reflecting this reality. Prior to release 11, the 3GPP specifications depicted the policy control and charging architecture as a “walled-garden” where communications providers would deliver additional content through various Application Functions (AFs). Many use cases that leveraged OTT traffic classification were impossible to realize by constraining implementation solely to the functions described in the standards. Network policy control solution vendors have always had to create additional, proprietary product features and functions that extend across gaps in the standards to enable complete solutions.

Release 11 3GPP specifications recognized the importance of OTT traffic identification in policy control with the introduction of the Traffic Detection Function (TDF) and Sd reference point. The TDF and Sd reference point are important steps towards aligning standards with the needs and functions of present day network policy control. Sandvine was instrumental in championing the needs of service providers by bringing charging functions to the TDF for 3GPP release 12, better acknowledging today’s service creation opportunities and challenges.

The latest standards have significantly closed the gap on what the industry refers to as “standards-lag”. However standards were never intended to fully specify all functionality but instead serve mainly to ease multi-vendor interoperability. The competitiveness of use cases that leverage functions to detect, measure, control and meter Layer-7 traffic depend less on compliance with the latest communication reference point than it does on vendor features built on top of a standards-based framework. This paper examines this reality in light of the 3GPP release 12 TDF and Diameter Sd reference point, demonstrating the difference between complying with the latest standards and having the ability to make critical use cases work.

Sandvine’s Approach to the 3GPP TDF Standards

3GPP technical specifications 23.203 and 29.212 version 12 describe the relationship between the TDF, Policy Control and Charging Rules Function (PCRF), Policy and Charging Enforcement Function (PCEF), various Diameter interfaces and other related elements such as the Online Charging System (OCS). The key aspect that determines compliance as a 3GPP release 11 or higher TDF is support for the newly introduced Diameter Sd reference point described in TS 29.212. Diameter Sd is used for communication between the TDF and PCRF using application detection and control (ADC) rules fully detailed in TS 29.212.\(^2\) Decisions about which applications to detect can be installed locally to a TDF and/or to what the specifications refer to as a “PCEF enhanced with ADC”; that is, a PCEF with an embedded ADC, which has embedded ADC rules.\(^3\) The PCEF uses Policy Control and Charging (PCC) rules and the Diameter Gx reference point to communicate with the PCRF (in place since release 7 and also described in TS 29.212). 3GPP release 12 introduced charging support to the TDF, effectively duplicating charging functions also described for the PCEF element. Both the TDF and PCEF elements must interpret monitoring keys from the PCRF and charging keys from the OCS.\(^4\) Indeed, the charging sections of TS 23.203 often describe the PCEF and TDF elements as one entity; for example, the credit

\(^1\) For detailed analysis of the latest and historical trends, see [https://www.sandvine.com/trends/global-internet-phenomena/](https://www.sandvine.com/trends/global-internet-phenomena/)


\(^3\) 3GPP TS 23.203 V12.2.0 (2013-09), section 4.5 [http://www.3gpp.org/ftp/Specs/html-info/23203.htm](http://www.3gpp.org/ftp/Specs/html-info/23203.htm)

\(^4\) Ibid.
management section of TS 23.203 is addressed at the “PCEF/TDF” element having or receiving “PCC/ADC” rules. Annex Q of TS 23.203 provides the following view of the logical relationship between these elements and their interfaces when online charging and an OCS are also in play:

![Diagram](attachment:image.png)

**Figure 1: Usage Monitoring via Online Charging System (3GPP TS 23.203 v. 12.2.0, Annex Q)**

**Functions vs. Use Cases**

Standards specifications are important guidelines that ensure efficiency across the industry as policy control vendors and service providers implement use cases to improve the bottom line. However, the 3GPP standards do not describe how to implement use cases such as congestion management, Layer-7 service creation (charging is not the same as the service being charged), and measuring adaptive video QoE for reporting, etc. Many vendors, including Sandvine, have built features on the framework of previous standards for the PCEF element to compensate for standards-lag - features that are now formally described as TDF functions in 3GPP release 12. Standards-compliance ensures interoperability between vendors and reduces deployment costs - Sandvine has completed interoperability testing with over a dozen PCRF vendors. However, it is the overall architectural approach (e.g., embedded vs. standalone, freeform vs. rigid-form policy, etc.) and the implementation of features built on a standards-compliant framework that makes use cases possible and truly differentiates one network policy control vendor from another. Whether based on release 12 or release 11, the following table shows that solutions have the same potential in terms of ultimate functionality:

<table>
<thead>
<tr>
<th>Functions</th>
<th>Release 12 TDF (Diameter Sd)</th>
<th>Release 9/11 “PCEF+” (Diameter Gx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTT Application Identification (DPI)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Application flow start/stop</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Usage monitoring and PCRF monitoring keys</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Measurement for charging and OCS charging keys</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Gating enforcement</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Redirection enforcement</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>QoS enforcement</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

5 Ibid, section 6.1.3.
These functions are mixed with vendor features to enable network policy control use cases for business intelligence, revenue-generation and cost-savings. In Sandvine’s current implementation, which has been deployed globally for several years and since long before the 3GPP release 11 standards were drafted, all communication with the PCRF occurs over Diameter Gx. The Diameter Gx protocol and PCC rules have been extended to support use cases for OTT application detection and control, with additional feature enhancements that offer unique advantages to service providers. Vendors, including Sandvine, will ultimately extend and enhance the Diameter Sd interface to incorporate proprietary features that they believe give their solution an advantage over their competitors.

Sandvine’s Policy Traffic Switch (PTS) deploys the Sandvine Policy Engine to the data plane and serves as a release 11-compliant PCEF for functions relevant to standalone network policy control. The PTS has provided the functions now described for the TDF in release 12 for many years - it provides traffic classification for Layers-3-7 with subscriber, location and device awareness, traffic enforcement, redirection, QoS-control and metering for charging.

The Service Delivery Engine (SDE) deploys the Sandvine Policy Engine to the control plane as a virtualized software element supporting PCRF functions that comply with 3GPP release 11 standards for Diameter Gx communication. The SDE can signal enforcement to other 3GPP-compliant PCEF elements and can map subscriber identities to bearers, locations and devices seen by the PTS, variables which can then be used as conditions in policy. It also provides standards-based record generation for any network type in support of offline charging applications.

Sandvine is currently developing support for the Sd interface, building its differentiating features onto the framework of 3GPP release 12. Use cases are currently supported using the Gx interface between the PCRF and an enhanced PCEF (PTS) that essentially duplicates all of the functions described for the TDF in the latest standards while adding the many advantages unique to Sandvine technology. There is currently nothing relevant to standalone network policy control described from a functional standpoint in the latest standards that Sandvine has not already implemented in support of the cost-saving and revenue-generating use cases that service providers truly care about in deployments around the world.
Sandvine Advantages and Use Cases

The following features and use cases offer unique benefits that transcend whether communication to the PCRF occurs over Diameter Gx or Sd.

SandScript and the Policy Engine

Using SandScript, users can build policies for the Sandvine Policy Engine from a vast library of possible conditions and actions. There is no limit to the number of dimensions that can be included (conditions, actions, measurements, logic loops, mathematical operations, policy groupings and interactions, cascading policies, etc.), nor to the number of policies that can be created.

Traffic classification

SandScript’s freeform capability enables the correlation of many distinct possible conditions, all analyzed in real time, to define a complex single policy that efficiently executes a wide variety of possible enforcement actions. Various possible policy conditions can trigger more than one enforcement action, such as “shape and notify via in-browser pop-up and SMS”, all defined within a single policy. The Policy Engine is installed on the data plane (PTS) and control plane (SDE). The Sandvine platform also exposes (for reporting or as conditions for policy control) information such as the subscriber’s device, their access network location, their overall QoE, their roaming status, the content delivery network (CDN) from which traffic originates, the quality of their video streams, and other important factors that enable unique use cases. Critically, Sandvine’s traffic identification is achieved without port-based dependencies, does not include false-positive-prone ‘suspected’ categories that play havoc with traffic management, and works in asymmetric networking environments (without relying on error-prone “statesharing” between appliances).

Rigid-form policy systems suffer from scaling issues, and the inability to construct complex policies to enable the extension of key PCRF decision functions required to support robust charging use cases.

---

6 For a detailed description how Sandvine manages asymmetric traffic with perfect accuracy, see Overcoming Asymmetric Routing and Extreme Scale in Intelligent Broadband Networks.
7 For more information see Technology Showcase: SandScript – The Advantage of Freeform Policy.
Extending 3GPP Element Functions to Support Use Cases

In the context of TDF functions, policy control equates to classifying subscriber service flows, managing (deciding and acting upon) the service flow for QoS or other attributes (policy control)\(^8\), and charging. Sandvine enhances Diameter Gx and PCC in support of advanced Layer-7 use cases with ‘named policies’ that can be used to activate behaviors, workflows and application-based traffic actions by the PCEF at the data intersect point. By extending PCRF decision functions to the data intersect point via the PTS, Sandvine’s real-time policy engine removes the need to constantly “pull” complex policies from a PCRF or wait for an application (via the AF) to “push” them. As a concrete example, a 3GPP PCRF may contain the names of several dozen video streaming and social networking plans. The 3GPP PCRF manages subscriber session-level decisions, including associating subscribers with plans, and sends this to the PTS. The PTS contains a detailed policy of how to manage the Layer-7 data flows on a per-subscriber basis for each plan. Decisions for rapid flow rates are made at the point where fast-changing conditions are detected - on the wire - eliminating concerns about latency caused by Layer-7 signaling operations, and analogous to the onboard ADC rules described for the TDF in TS 23.203.\(^9\)

![Figure 4: Sandvine Platform and 3GPP element functions](image)

Ultimately, this strategy allows Sandvine’s network policy control platform to trigger the right policy at the right place and time, and for the right subscriber and device.

Measurements

Sandvine’s measurements are linked directly to the Sandvine Policy Engine, enabling real-time network policy control based on an infinitely-versatile infrastructure. For instance, a measurement of increasing round-trip time (i.e., decreasing subscriber QoE) can, in real-time, initiate congestion management policies. Or, real-time counting of bytes against a quota can trigger a subscriber notification of quota exhaustion. The network policy control possibilities are literally endless, because measurements can be leveraged in any combination to trigger a wide range of policy enforcement and charging actions. In all likelihood, if you can express a policy control objective, you can achieve it with the Sandvine Policy Engine.

---

\(^8\) This may include measurements for reporting on the QoS and other attributes.

\(^9\) For more information about the value of extending 3GPP element functionality, see the whitepaper *Distributed Decisions in Network Policy Control.*
Traditional Traffic Identification

“Netflix consumes 3.5 Gbps on our network and there were some TCP packet drops”

<table>
<thead>
<tr>
<th>Sandvine Traffic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Netflix consumes 3.5 Gbps on our network”</td>
</tr>
<tr>
<td>“23.6% of our subscribers are Netflix customers, but 34.7% went to Netflix.com last month”</td>
</tr>
<tr>
<td>“The median duration of a Netflix video on our network is 42 minutes and is increasing by one minute per month”</td>
</tr>
<tr>
<td>“The top device by bytes is the Playstation 3”</td>
</tr>
<tr>
<td>“The top device by minutes is the Wii”</td>
</tr>
<tr>
<td>“The top Roaming@home device is the iPhone”</td>
</tr>
<tr>
<td>“Last Month, 30% of videos viewed were HD, but this month 33% are HD”</td>
</tr>
<tr>
<td>“The average user watches 33 videos per month”</td>
</tr>
<tr>
<td>“The average quality of experience is 4.1 out of 5, and is abnormally low in our East region”</td>
</tr>
<tr>
<td>“Two of our CDNs are delivering an average QoE better than 3.5, and one CDN is very poor”</td>
</tr>
</tbody>
</table>

Sandvine’s use of freeform policy means that, since data are measured and stored independently, aggregations are orthogonal - that is, they can be combined and executed in any order. For example, you can answer the question, “How many subscribers on each mobile base station are tethered”, as easily as, “What is the median volume of Netflix traffic from Android users enrolled in our Gold service plan? How does this compare with iPhone users?” All the variables are considered independently, whereas competing technologies using rigid-form policy to institute strict hierarchies that force operators to frame business intelligence queries in a specific, limited manner, hindered by the groupings defined in the product.10

Use Case – Measuring Adaptive Video QoE

Sandvine’s traffic classification approach uniquely enables the measurement of adaptive video QoE, completely independent of whether communication with the PCRF occurs over Diameter Gx or Sd. To properly measure the quality of both progressive and adaptive streaming video, interim video quality measurements are made throughout the duration of a video session’s life by the PTS and reported to the SDE, which calculates the QoE score for the entire session. In particular, adaptive video has an additional ‘protocol’ layer and also uses several layers to get data to the client for viewing by the subscriber. The information and measurements taken to accurately classify adaptive streaming video and specify the actual quality of individual streams include11:

- IP: Subscriber, CDN, BGP AS path (same as progressive)
- Subscriber: physical location on network, service plan, device type (same as progressive)
- TCP: (same as progressive)
- HTTP: asset (used to link multiple chunks together), ‘protocol’, CDN
- Protocol: duration, stall information (transport quality)
- Container: codec, resolution, bitrate (display quality)
- Elementary stream: bytes transferred (same as progressive)

10 For more information see Technology Showcase – Sandvine Traffic Classification
11 For more information see Measuring Over-the-Top Video Quality
Usage Management

It is important to note that charging functions are essentially interchangeable between the TDF and PCEF in 3GPP release 12. A release 11 PCEF for standalone network policy control enhanced with traffic detection and other vendor features provides the same charging functionality as a release 12 TDF. The SDE’s SandScript policy language offers agile control plane policies and subscriber-tailored services, and the PTS provides extensive data plane Layer-7 flow evaluation. Sandvine’s on-wire decision capability ensures minimal latency for charging enforcement and subscriber notification, as well as maximum revenue retention. This feature and full compliance with the Diameter Gy standard allows the solution to be fine tuned for OCS communication for maximum metering accuracy with no overshoot or undershoot.

SandScript-enabled features such as Turnkey Provisioning allow rapid in-field service plan adaptation to quickly capitalize on emerging revenue opportunities. These features will continue to exist and operate within the Sandvine platform before and after the transition from full Gx communication with the PCRF to the combined Gx/Sd communication currently described by the latest standards.12

Use Case - Third-Party Promotion

In this particular example, a new service package offers zero-rating of gaming traffic bundled with a popular retail game. Turnkey provisioning quickly defines the behavior of the solution for each new subscriber that signs on. The SDE maps subscribers to policy, managing family plans and the higher level quota logic. The PTS identifies the gaming traffic for zero-rating and meters traffic using its on-wire flow evaluation capability (the PCRF function extension) for extreme precision to ensure a positive customer experience with maximum revenue retention.

Figure 5: Example Third-Party Promotion Enabled by Sandvine

At no point does the fact that communication occurs with the PCRF over Diameter Gx instead of Sd have any impact on this or any other use case.

Traffic Management

The ability to manage traffic depends less on compliance with the latest standards than it does on the capabilities of the enforcement platform. Sandvine supports precise shaping (including weighted fair queuing), minimum rates for QoS-controlled traffic, and the ability to use real-time measurements as a trigger for real-time enforcement.

12 For more information see Standards-based Online Charging – Maximizing Utility and Technology Showcase – Quota Manager.
Use Case - Automated Network Congestion Management

Sandvine's Fairshare Traffic Management includes a feature called QualityGuard that measures latency in the access network and automatically responds to congestion events to protect subscriber QoE and extend the life of access network resources. The ability to perform real-time measurements at the data intersect point uniquely supports a closed-loop response system that automatically eliminates congestion. The business intelligence revealed by this feature is also critical for congestion monitoring and confident capacity planning. Figure 6 provides a conceptual reference for how QualityGuard functions. In this case, QualityGuard has been configured to take action when detected subscriber QoE falls below a real-time quality score of 85, which corresponds to an aRTT latency measurement of about 250ms.

Figure 6 - QualityGuard congestion response in practice

Again, it’s important to note that this use case and the QualityGuard feature are oblivious in terms of the interface used to communicate with the PCRF, whether through extended Diameter Gx or Sd.13

---

13 For more information see Technology Showcase - QualityGuard
Conclusion

The TDF and Sd reference point are important steps towards aligning standards with the needs and baseline functions of present day network policy control. These latest standards have significantly closed the gap on what the industry refers to as “standards-lag”, but there will always be a need for proprietary features that meet present-day realities.

This paper has shown that it is the overall architectural approach (e.g., embedded vs. standalone, freeform policy vs. rigid-form, etc.) and the implementation of features (e.g., on-wire PCRF functions) built on the framework of the 3GPP standards that make use cases possible and differentiate one network policy control vendor from another.

There is currently nothing relevant to standalone network policy control described from a functional standpoint in the release 12 standards that Sandvine has not already implemented in support of the cost-saving and revenue-generating use cases service providers truly value.