TELECOMMUNICATION ENGINEERING CENTRE
दूरसंचार अभियांत्रिक केन्द्र
MINISTRY OF COMMUNICATIONS AND INFORMATION TECHNOLOGY
संचार एवं सूचना प्रोधोगिकी मंत्रालय
DEPARTMENT OF TELECOMMUNICATIONS
दूरसंचार विभाग
GOVERNMENT OF INDIA
भारत सरकार
ISO 9001:2008

STUDY PAPER ON
POLICY AND CHARGING RULE FUNCTION

Table of Contents

1. **Introduction** 2
2. **Definition of PCRF & Need** 2
3. **PCRF – The Architecture** 4
4. **Deployment of PCRF in Telecom Network** 6
5. **Call Flow with PCRF** 9
6. **Advantages of Policy Server** 10
7. **PCRF Market Forecasting** 11
8. **Conclusion** 12

GLOSSARY 13
REFERENCES 13

Policy and Charging Rule Function

(1) Introduction

The convergence of broadband access, virtually unlimited content and smart mobile devices has permanently altered the telecommunications market. Demand for mobile Internet services is rapidly increasing day by day as customers want to receive their content, media and applications on any device at any time. For the last few years, the telecom industry is radically transforming the revenue streams, business models and value chains.

To remain relevant in this rapidly changing environment, telecom operators must address critical challenges to create new business models and reinvent themselves.

Therefore, Service Provider must have some statistics that determine how and under what conditions subscribers and applications use network resources for formulation of the policies. The Policy Server manages policy rules between applications and policy enforcement points like access devices. It can easily add and re-configure policies to dynamically manage and control Quality of Service (QoS), charging, quota, optimization and admission control. A wide variety of interfaces make it easy to integrate the PCRF with any type of mobile or fixed broadband network.

Since operators will be migrating from 2G to 3G to 4G networks in years to come, existing networks must operate concurrently with newer networks. As subscribers travel between mobile networks, and also the fixed network, operators must be able to maintain session visibility. As a result, policy solutions must be able to dynamically control sessions per subscriber.

PCRF can provide a network agnostic solution (wire line and wireless) and can also enable multi-dimensional approach which helps in creating a lucrative and innovative platform for operators. PCRF can also be integrated with different platforms like billing, rating, charging, and subscriber database or can also be deployed as a standalone entity.

The aim of this study paper is to briefly explain the features of PCRF and advantages of it after implementation in network.

(2) Definition of PCRF & Need

Policy and Charging Rules Function (PCRF) is a node which functions in real-time to determine policy rules in a multimedia network. As a policy tool, the PCRF plays a central role in next-generation networks/LTE. It is a component that operates at the network core and accesses subscriber databases and other specialized functions, such as a charging system, in a centralized manner. The PCRF has an increased strategic significance and broader potential role, than traditional policy engines, due to its working in real time.

The PCRF is the part of the network architecture that aggregates information to and from the network, operational support system and other sources (such as portals) in real time, supporting the creation of rules and then automatically making policy decisions for each subscriber active on the network. Such a network might offer multiple services, quality of services (QoS) levels, and charging rules.

It provides:

- The ability to manage network and subscriber policy in real time.
- The ability to efficiently and dynamically route and prioritize network traffic.
- Unified view of subscriber context based on a combination of device, network, location and billing data.
- Key inputs to revenue assurance and bandwidth management.

Need for PCRF - Following two cases describe the need of PCRF in telecom network.

2.1 Changing Revenue Streams

In many developed telecom markets, voice revenue has gained a peak and has declining trends. Messaging is expected to increase globally significantly in coming years. New IP message services like iMessage and WhatsApp are beginning to attract consumers' attention, particularly those with smart phones. As the IP messaging phenomena takes off, SMS messaging revenues will also decline.
Data access is still a growth engine for operators and is helping in compensating the decline in voice and messaging revenues. In major markets, data demand is doubling each year, but margin pressure is intense. At present, expenditure incurred in building network capacity to handle the increasing load is more than the revenue earned by data access.
In view of above, operators need to plan new revenue streams. For implementation of this operators need a PCRF type entity in their telecom network.

2.2 Business Transformation Starts with the Network

Existing telecom networks are not built with the DNA(Dynamic Network Administration) to foster innovation and respond quickly to dynamic markets to meet the demands of the subscribers. To reinvent themselves, operators need to redesign their legacy infrastructure into a highly evolved, completely software-defined network (SDN) –the thinking network. The thinking network is analogous to the human body. The memory is the subscriber database. The language is the Diameter protocol, the central nervous system is the new product category of Diameter Signaling Controller (DSC), and the brain is policy.

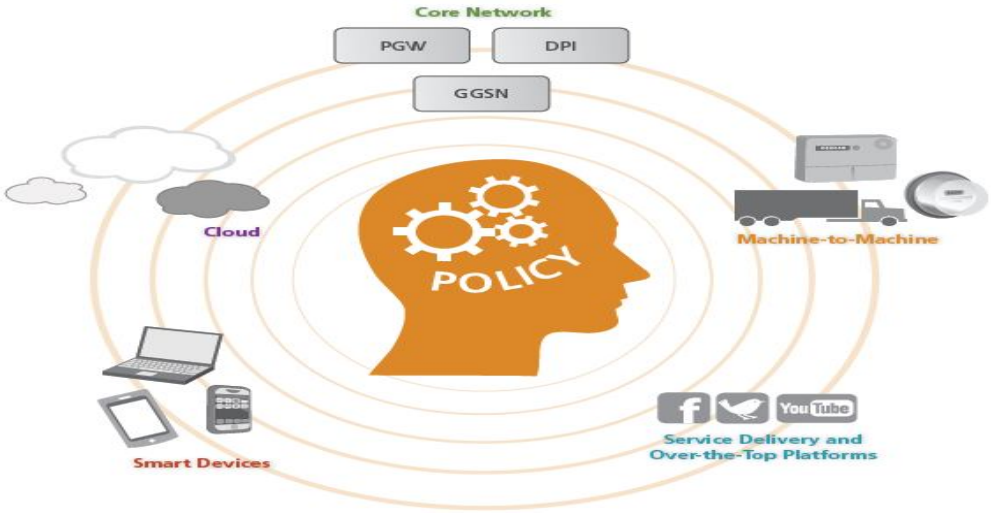

Figure 1 : **Thinking Network**

(3) PCRF - The Architecture

PCRF was introduced in September 2007 when standards for the 3GPP Policy Charging Control (PCC) architecture were published. The PCRF function is part of the larger PCC architecture, which also includes the Proxy Call Session Control Function (P-CSCF) and the Policy and Charging Enforcement Function (PCEF). Combined, the elements of the PCC provide access, resource, and quality-of-service (QoS) control.

PCRF is an important part of IMS architectures, although it is not exclusive to the 3GPP-based network in which it was certified. It works across wireless networks and can be deployed on carrier grade/ATCA (Advanced Telecommunications Computing Architecture)/COTS (Commercial off the shelf) hardware.

The PCRF interfaces with the main packet gateway and takes charging enforcement decisions. The centralized device can act as a policy decision point (PDP) for the wireless operator and goes down to the individual subscribers.

Service providers can use PCRF to facilitate for charging of subscribers based on their volume of usage of high-bandwidth applications and charging based on QoS guarantees, limit app usage while a user is roaming, or lower the bandwidth of wireless subscribers using heavy-bandwidth apps during peak usage times.

PCRF Server is carrier grade platform used to implement the convergent policy management, real-time policy decision solutions across core network domain and content application domain for the network service providers.

PCRF Server includes a 3GPP-compliant implementation of Policy and Charging Rules Function to provision, manage and execute the Quality of Service policies, Bandwidth control policies, Subscriber-aware policies, and Application gating policies in the 2G/3G and LTE networks.

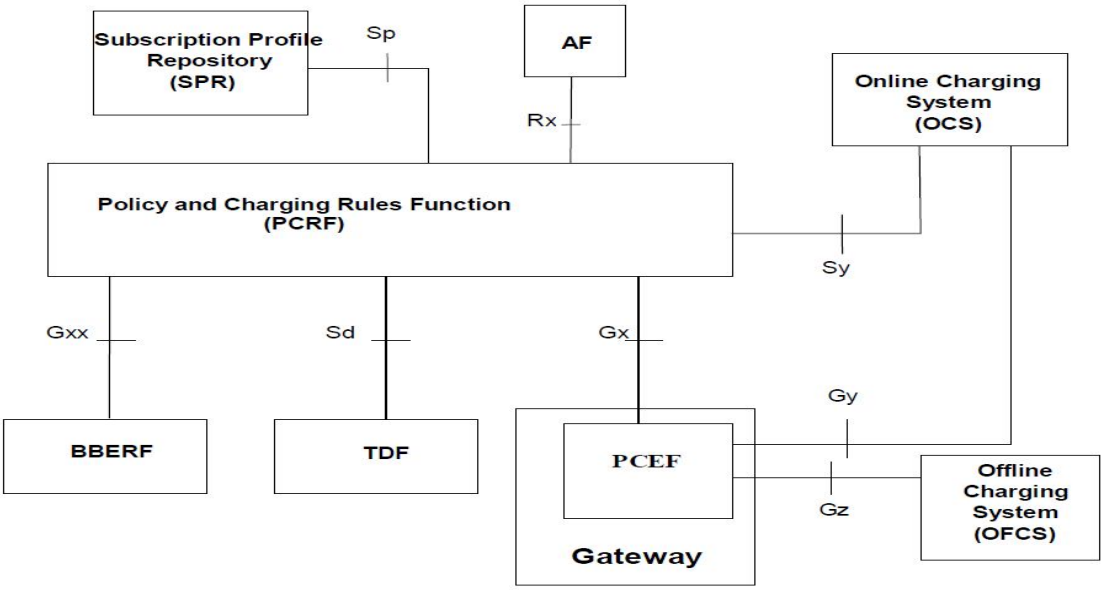

Figure 2 :as per 3GPP TS 23.203

Legends: *PCEF : Policy and Charging Enforcement function*
TDF : Traffic Detection Function, AF : Application Function
BBERF : Bearer Binding and Event Reporting Function

PCRF is comprised of the following components/subsystems

a. One or more policy servers which provides the policy and charging management functions
b. Subscriber Profile Repositories (SPR)
c. A Configuration Central Management Subsystems for centralized provisioning and management of the policy servers

(a) Policy Server

The PCRF SERVER is the main server engine that processes the policy requests from the core network elements or B/OSS (Business/Operations Support System) systems at real-time. The main components of the PCRF Server are the Diameter-based 3GPP Gx, Rx, Sy, Gxx, Sp and Sd Connectors, Policy and Charging Rules Server, Policy Decision Platform, Subscriber Profile Cache and Subscription Management Service.
The Policy Server has a rules engine and acts as the standards based Policy Charging and Rules Function (PCRF) in the network. The rules engine operates on triggers, processes conditions, and then performs appropriate action(s) based on the conditions. The rules engine can be invoked based on any interface trigger. The rules engine can be triggered by a message from either the GGSN or DPI via either the Gx interface, the SPR via the Sp or SOAP/XML interface, as well as the application function via the Rx interface. The rules engine can also be triggered by internal timers which can be used to support a variety of time of day based applications/use cases. Policies can be developed quickly using Policy Rules wizard.

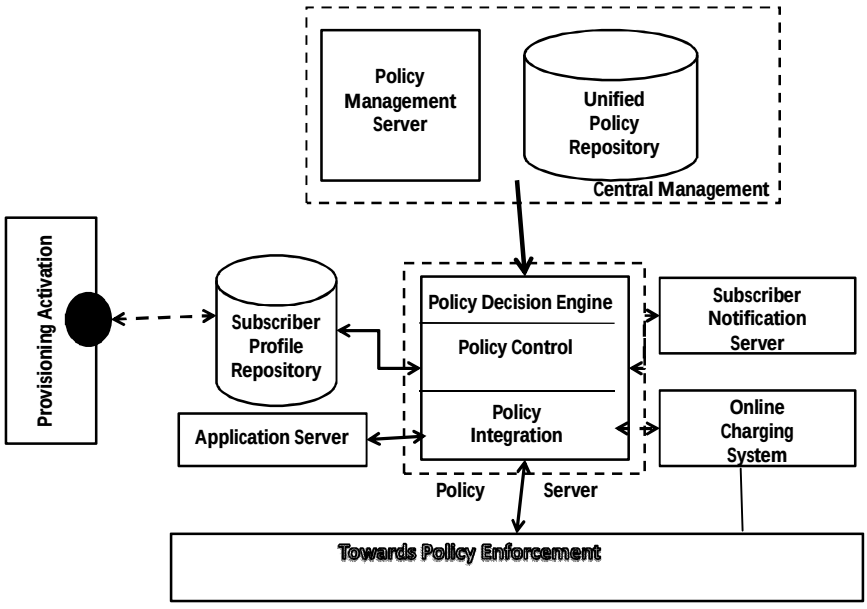

Figure 3 : PCRF's Subsystems

(b) SPR- Subscriber Profile Repository

SPR is the repository to store all business assets, technical assets and configuration items used by the PCRF Server, Central Management Server. This is a mandatory component to run PCRF Server.
Policy's SPR should act as the policy solution database to store subscriber profile, quota, and state information of the Policy Server to use in its policy execution. The SPR should be deployed in networks to store subscriber profile information and inter-session state information (e.g. usage and quota tracking). The SPR should be deployed in a variety of configurations according to the customer needs and requirements e.g. in a standalone redundant HW configuration or together with the other PCRF components within the same platform.

(c) Policy Management Platform/Central Management Subsystem

Central Management Subsystem is the centralized server node to monitor and manage the PCRF Server and Repository Server. It's the core component for PCRF Server to provide the OA&M functions. The Management Platform provides a consolidated view of system alarms and logs and has SOAP/ XML API to interface to external systems.

In addition to above , PCRF server may also have following Components /functionalities :

(a) SPR Proxy subsystem - It is a component that exposes the Web Services API within PCRF Server for management of the internal Subscriber Profile Repository (that is, subscriptions and subscribers).
(b) Load Balancer – It is the key component in the distributed deployment environment for PCRF Server. It provides the Diameter application level load balancing capability

(4) Deployment of PCRF in Telecom Network

Following are the architecture of telecom network with PCRF.

(A) PCRF with 2G/3G Network

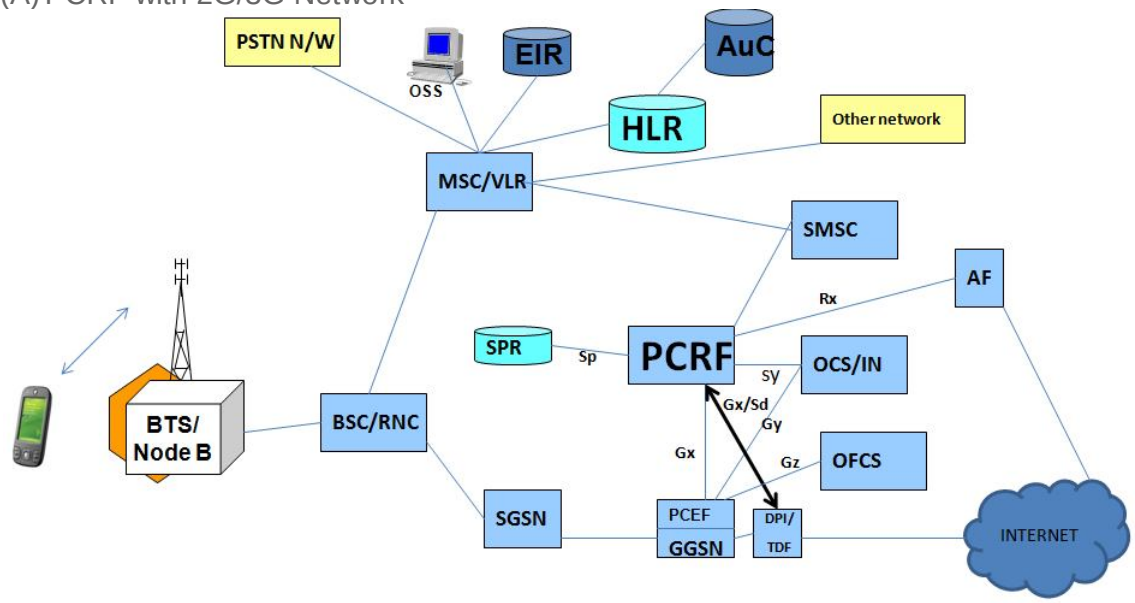

Figure 4

(B) PCRF with 4G/LTE Network

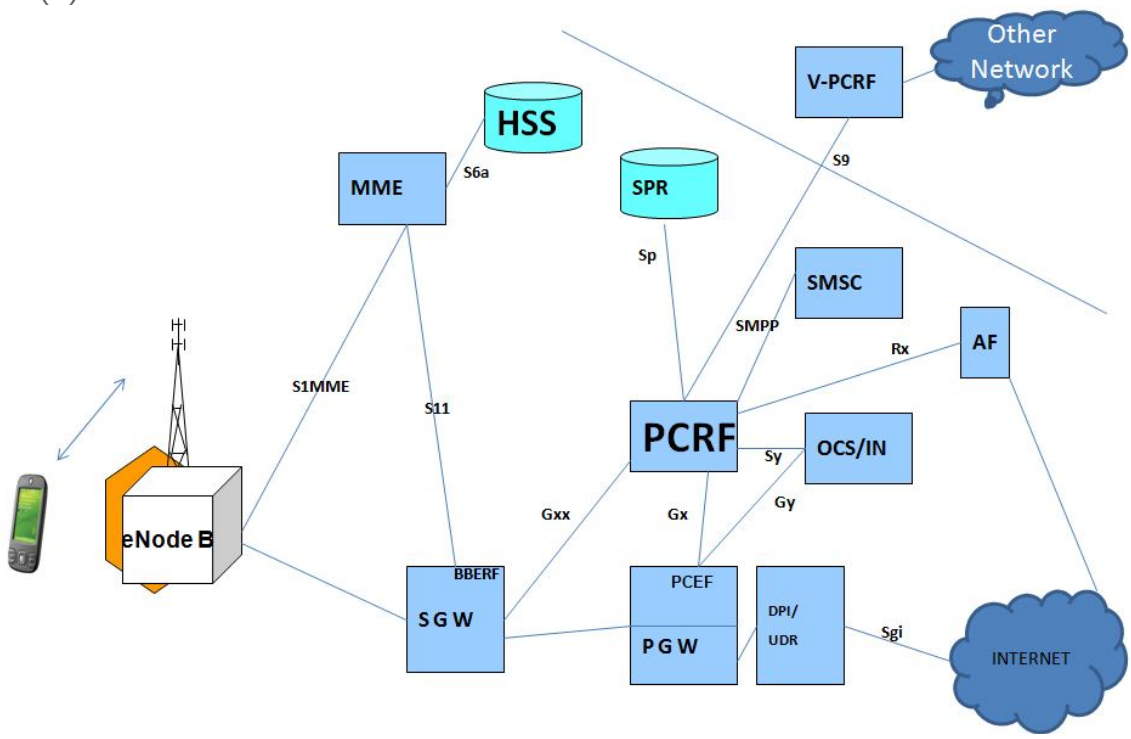

Figure 5

(C) PCRF in converged network

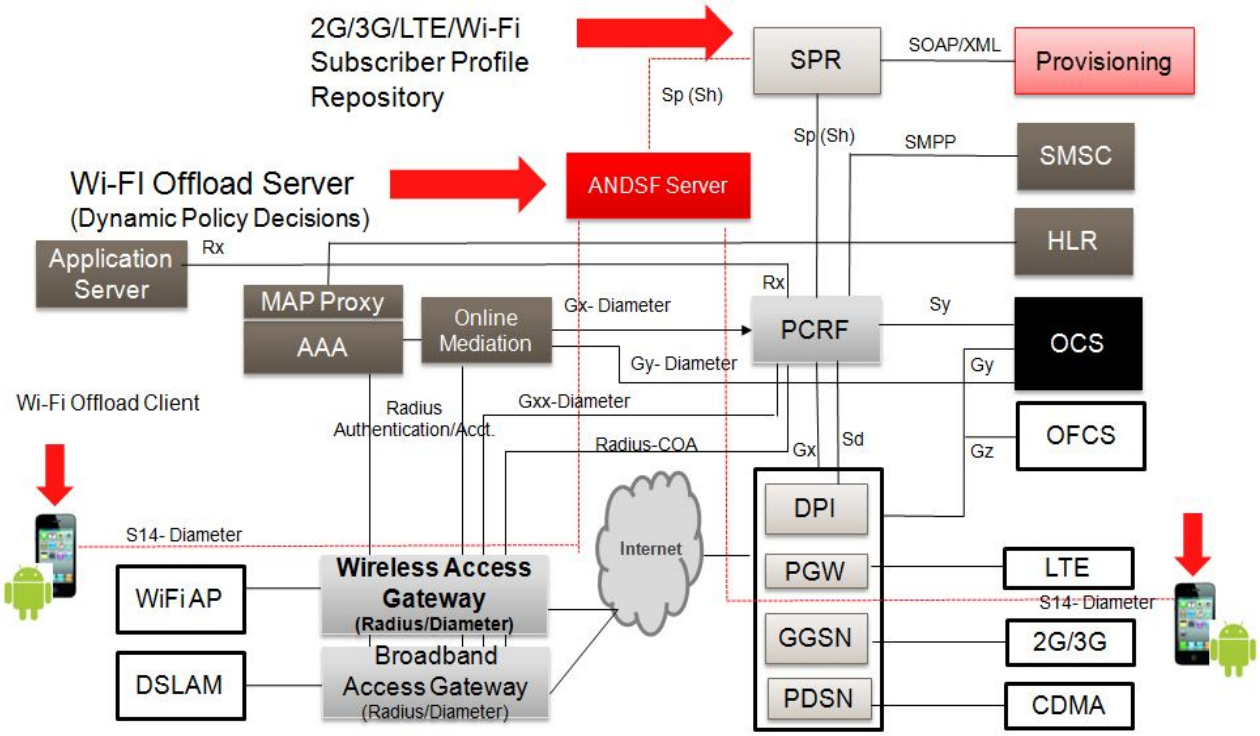

Figure 6

Following are the description of used external interfaces supported by PCRF Server:

(i) Gx Interface - PCRF Server supports the Gx interface as defined in 3GPP Release 7, 8, 9 and 10 . It is used for provisioning service data flow based on charging rules. It is located between the PCRF and the Policy and Charging Enforcement Function (PCEF). In most cases, PCEF is based inside PDN GW(Packet Data Network Gateway) or in short PGW, as in above diagram. PCRF Server is very flexible and can be configured to support any specific AVPs in the network element and accommodate customer specific scenarios.

(ii) Gy Interface - PCRF Server supports the Gy interface and acts as DCCA proxy between PCEF and OCS(Online Charging System). This interface allows online credit control for service data flow based charging.

(iii) Gz Interface – This is used for offline(CDR based) charging interface between the PCEF/PDN GW and OFCS (Offline Charging system).

(iv) Rx Interface - PCRF Server supports the Rx interface as defined in 3GPP Release 10. This reference points is used to exchange application level session information & media related information between the PCRF & Application function/Application Server. This information is the part of the inputs used by the PCRF for the Policy and Charging Control Decisions.

(v) Sy Interface - PCRF Server supports the Sy interface as defined in 3GPP Release 11. It is used between PCRF and OCS for sending limits reports.

(vi) Sp Interface - PCRF Server supports the Sp interface between the PCRF and the SPR. This interface allows the PCRF to request subscription information related to transport level policies from the SPR based on a subscriber ID, a PDN identifier and possible further IP CAN session attributes, as specified in 3GPP TS 23.203 v9.x. This interface allows the SPR to notify the PCRF when the subscription information has been changed if the PCRF has requested such notifications. The SPR shall stop sending the updated subscription information when a cancellation notification request has been received from the PCRF.

(vii) Ud Interface - PCRF Server supports the Ud interface between the PCRF and the UDR. This interface allows the PCRF to create, read, modify and delete user data stored in the UDR using the access interface. It is based in LDAP. This interface supports subscriptions/notifications functionality to allow the PCRF being notified about specific events that may occur on specified user data in the UDR. The events can be changes on the existing user data, addition of user data, and so on. PCRF Server supports the Ud interface based on LDAP protocol, as defined in 3GPP TS 23.335 v9.x and TS 29.335 v9.x.

(viii) RADIUS Interface - PCRF Server provides a RADIUS based AAA interface which is connected with external AAA server. It receives the AAA-Start and AAA-Stop radius message forwarded from AAA server when IP-CAN session is

established or terminated. It works with AAA management (component that provides the mapping between the IP Address and the MSISDN) to manage the mapping between IP address and MSISDN.

(ix) **RADIUS CoA Interface** – Radius Change of authorization (CoA) features provides a mechanism to change the attributes of an authentication, authorization and accounting (AAA) session after it is authenticated. When a policy changes for a user or user group in AAA, administrators can send the Radius CoA packets from the AAA server to reinitialize authentication and apply the new policy. PCRF Server also provides the connector and the processing flow used to provision policy rules to a non-3GPP enforcement point via RADIUS / RADIUS CoA interface.

(x) **Gxx Interface** – This reference point resides between the PCRF and the BBERF(Bearer Binding and Event Reporting Function). The Gxx reference point enables a PCRF to have dynamic control over the BBERF behaviour. The PCRF PCC rule decisions may be based on information obtained from the BBERF via the Gxx interface. BBERF generally resides in the SGW.

(5) Call Flow with PCRF

In 2G/3G Network

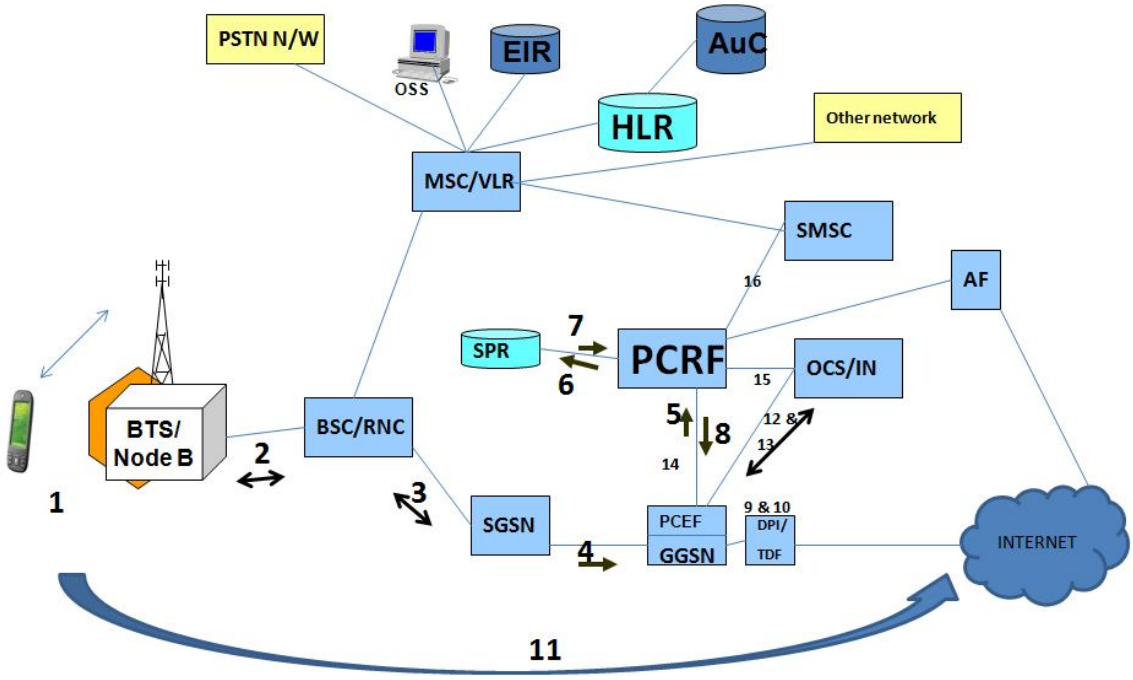

Figure 7

CALL FLOW PROCEDURE:

(1) User equipment(Mobile Station) wishes to establish a data application(data access/internet), so it request to BTS/Node B.
(2) Node B forward its request to BSC/RNC.
(3) After all queries and procedure related to authentication, IMEI check & subscriber static information(HLR), BSC/RNC forward subscriber request to SGSN. Some of the queries are performed by SGSN.
(4) SGSN requests to GGSN for PDP context/data access.
(5) GGSN signals/query to PCRF(Policy & Charging Rule Function) about UE/MS data session establishment over Gx interface.
(6) PCRF queries the Subscriber Profile Repository(SPR) for dynamic information of subscriber over Sp interface.
(7) SPR sends all information about the subscriber policy/quota/rules to PCRF over Sp interface.
(8) PCRF installs policies for subscriber on GGSN(by PCEF)(per access point name[APN] and per bearer quota grants).
(9) If required, over Gx interface, Deep Packet Inspection(DPI) intimates PCRF on traffic detection.(Ud interface in the case of TDF[Traffic Detection Function])
(10) PCRF installs policies for application control on DPI and DPI begins tracking usage.
(11) Now data session is established and the subscriber starts consuming the data.
(12) Over Gy interface GGSN/PCEF talks to OCS(Online Charging System) for charging/credit.
(13) GGSN receives the information from OCS about balance/quota.
(14) GGSN signals policy server(PCRF) that device has exceeded data/quota grant or credit is low.
(15) Over Sy interface OCS also sends the credit limit report to PCRF.
(16) Policy server may grant additional grant, after consulting with subscriber by sending SMS notification over SMPP.

(6) Advantages of Policy Server

In the intelligent network model, policy is the engine for innovation and differentiation. Its role evolves dramatically from its current usage, expanding both in application and scope.
To succeed as digital lifestyle providers, service providers require advanced tactics and tools that enable them to:

- Create a policy foundation that scales as the number of applications, use cases and network demands grow;
- Leverage network assets and analytics to gain a granular view of subscriber, application and network behaviour from the handset to the core;
- Focus squarely on the subscriber with a rich service experience that's tuned to each consumer's behaviour and provides direct personal benefit;
- Expand traditional, one-sided business models to engage and partner in new markets - machine-to-machine (M2M), over-the-top (OTT), mobile advertising, and cloud;
- Develop flexible, dynamic pricing strategies that address multiple market segments and offer end users more choices that reflect their usage patterns and lifestyles; and
- Respond dynamically, often in real-time, to changing market and network dynamics.

With the ability to push policy control beyond the network core to its edge, operators can develop creative strategies to:

• **Optimize and personalize each subscriber's experience.**
Operators can create a service experience that is related to each subscriber based on preferences, location, access network, device type, and network conditions. They can provide a relevant mobile advertisement, or inform the subscriber when a usage threshold is reached to prevent bill shock. Or, a service provider can zero rate social networking usage so it doesn't count against the subscriber's data bucket. Operators can offer service plans that guarantee bandwidth for certain high-value customers like corporate accounts, create flexible pricing plans that match a subscriber's preferences and budget, or allow subscribers to share one quota across multiple devices.

• **Create lucrative, two-sided business models with third-party, OTT and cloud providers**.
Operators hold a number of valuable assets – QoS, security, billing relationships, subscriber profiles, context, usage, and device awareness – that can be used to create profitable commercial relationships. They can enable targeted third party advertising. Operators can offer identity as a service, enabling subscribers to use their network identity as a single-sign-on for third-party applications. Or, they can leverage the trusted relationship they've established with subscribers to provide secure, consolidated billing for OTT and cloud applications.

• **Maximize resources and Manage QoS**.
Operators can implement creative solutions to manage network congestion. Advanced Wi-Fi offload use cases based on preferential network access, subscriber tier or type, device, application, quota, or network conditions can be implemented to relieve congestion on licensed spectrum and improve subscribers' data experience. A device can be moved to the best available network to ensure that the subscriber application usage receives the best available QoS based on current network conditions. The impact of high bandwidth applications can be minimized by offering subscribers incentives to shift their usage to a different time of day or less congested location. With advanced policy tools, operators can reduce the effect of the excessive signalling generated by "chatty" apps that constantly query the network.

(7) PCRF Market Forecasting

Presently deployment of PCRF is being done. Many Research Organisation did forecasting about PCRF Market as below:

Research Organization	Last Update	Forecast
ABI Research	Nov 2013	$3B/2018
Dell'Oro Group	Aug 2013	$900M/2017
Heavy Reading	May 2013	$2.9B/2017
Stratecast (F&S)	Apr 2013	$2.4B/2017
Infonetics Research	Mar 2013	$2.4B/2017
Yankee Group	Nov 2011	$1.4B/2015
Analysys Mason	Feb 2011	$1.1B/2015

(8) Conclusion

Policy and Charging Rules Function (PCRF) - supports service data flow detection, policy enforcement and flow-based charging. It offers a comprehensive solution that allows a new generation service provider to offer multiple use cases that allows them to better control their services and align their revenue with their resources.

PCRF Server provides a flexible and scalable software platform for the development and management of any type of policy solutions specialized for telecom industry. PCRF Server also offers flexibility in integration with various core network equipment or B/OSS systems using industry standard (e.g. 3GPP) or non-standard interfaces/protocols. PCRF Server enables the rapid prototyping and provisioning of new policies or products for innovative and unique services/applications to the subscribers.

As operators transition to LTE, policy will play a critical network role and become a strategic component in the quest to manage and monetize LTE networks. Virtually every LTE session and subscriber will need to be managed or charged in some fashion, which will require the involvement of a policy server in each transaction. From prioritization to personalized service plans, the coupling of LTE with policy promises to help resolve key LTE operational and business challenges and support a new generation of revenue generating services. Equipped with intelligent policy management, operators can shape and manage network demand, revenue contributions from differing classes of customers, capital expenditures, and overall growth of the LTE, mobile broadband market.

GLOSSARY

3GPP : 3rd Generation Partnership Project
AF : Application Function
ATCA : Advanced Telecommunications Computing Architecture
BBERF : Bearer Binding and event reporting function
B/OSS : Business/Operations Support System
COTS :Commercial off the shelf
DCCA : Diameter Credit Control Application
DPI : Deep Packet Inspection
DSC : Diameter Signalling Controller
GGSN : Gateway GPRS Serving Node
IMS : IP Multimedia Subsystem
LDAP : Lightweight Directory Access Protocol
LTE : Long Term Evolution
OMC : Operation & Maintenance Center
OTT : Over the Top Platform
PCC : Policy & Charging Control
P-CSCF :Proxy Call Session Control Function
PCEF : Policy and Charging
PCRF : Policy & Charging Rule Function
PDF : Policy Decision Function
PGW : Packet Gate way
QoS : Quality of Service
SDN : Software Defined Network
SMS : Short Message Service
SMTP : Simple Mail Transfer Protocol
SMPP : Short Message Peer to Peer
SNMP : Simple Network Management Protocol
TDF : Traffic Detection Function
UDR : User Data Repository

REFERENCES

(1) ITU-T (www.itu.int/en/ITU-T)
(2) 3GPP (www.3gpp.org)
(3) Policy Charging & Control Architecture (3GPP TS 23.203)
(4) Survey of Research Organisation
(5) http://broabandtrafficmanagement.blogspot.in/p/dpi-market-size-forecast.html