broadband forum

APP NOTE

Cloud-CO-APPN-445: Monitoring, Diagnostics, and Optimization in a Residential Broadband System

Editor(s) and Contributor(s): Ken Kerpez
Supporting Company/ies: ASSIA Inc.

Table of Contents

1 Summary/Objective

Wireline residential broadband services (e.g., xDSL, G.(mg)fast, Passive Optical Network (PON) and Cable all have multiple potential areas of service and performance impairment, including possible modes of failure. Status and performance monitoring, fault diagnostics, and optimization of line configuration parameters is especially important for copper-based technologies such as xDSL and G.(mg)fast, and is also important for PON and Cable. Consequently, effective performance, fault and configuration management are key for broadband service.

Compared to established management architectures, CloudCO systems offer significant functional flexibility. They also have the potential to dedicate more computational and storage resources to monitoring, diagnostics and optimization functions than individual network elements, enabling high-power analyses. In particular, large datasets can be used to correlate diagnostics across many lines or services. Locating functions near equipment in a CloudCO allows rapid reaction, agility, component re-use and flexible allocation of compute, memory and interfaces. Monitoring, diagnostics and optimization often benefit from rapid reaction which can be faster using a CloudCO instead of using traditional centralized management systems. Reusable “Virtual probe” software interfaces to network elements through the BAA and can be readily updated with resources scaled on demand.

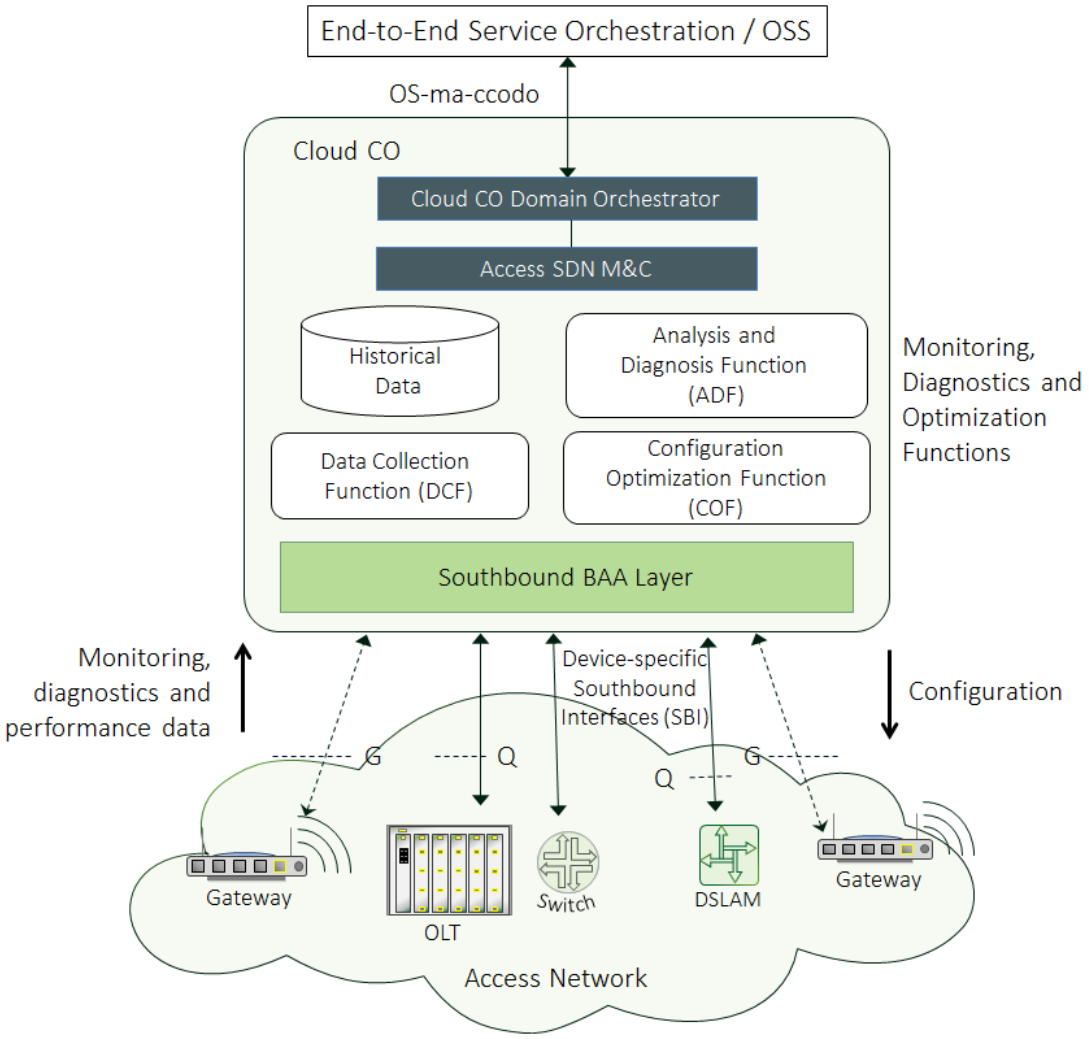
This application note establishes how to instantiate and run functions in a CloudCO which obtain monitoring and diagnostics data in a residential broadband system, as well as optimizing line configuration parameters.

2 Assumptions and Preconditions

1. The CloudCO Domain instance is already fully bootstrapped.
2. The Network Elements consist of access network equipment PNFs, e.g., access nodes including DSLAMs/DPUs for xDSL and G.(mg)fast, OLTs and ONUs for PON; edge switches, etc.
3. The physical connectivity between Access PNFs and BAA has been established.
4. The physical connectivity between Premise PNFs (RGs) at the home premise, Access PNFs, and BAA has been established.
5. CloudCO Controllers are applications running inside the NFVI and Controllers can talk to the elements they manage. This was established in a previous bootstrapping stage (See CLOUDCO-APPN-000).
6. VNFs for the DCF, ADF, and the COF are available and ready for onboarding.
7. External orchestration / OSS is able to provide instructions for Monitoring, Diagnostics, and Optimization, and to provide addressing and credentials for connecting to the equipment.

3 Description of the System

This App note builds on the initial CloudCO use case in TR-416, Clause 6.1.4 Residential Broadband Access Monitoring, Diagnostics, and Optimization.



The above figure is a generalization of the DSL Quality Management (DQM) systems functional architecture [BBF TR-198i2]. Here, the Diagnostic Collection Function (DCF), Analysis and Diagnosis Function (ADF) and Configuration Optimization Function (COF) are are hosted together in the CloudCO, and so may use powerful algorithms and data analyses, with rapid reactions. The Southbound Q-interface connects to access nodes using legacy protocols or NETCONF/YANG. The Q-interface is used to manage access nodes and broadband lines, while separately the G-interface is used to manage CPE. The G-interface generally uses the CPE WAN Management Protocol or User-Services Platform (USP) to connect to RGs. This App note considers the BAA Southbound to encompass connections through both the Q-interface and the G-interface.

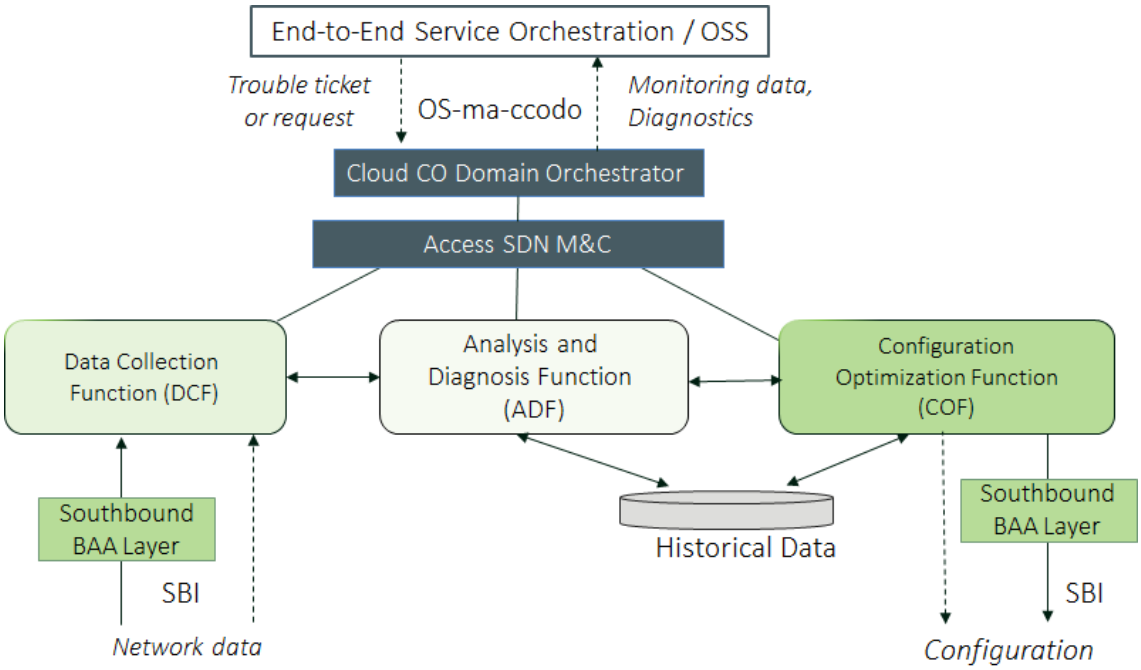
Broadband monitoring, diagnostics and optimization can also extend into the home LAN, e.g., for in-home Wi-Fi; then the G-interface is vital. Agents in the CPE can communicate to controllers in the CloudCO communicating with the USP across the G-interface. For example, Wi-Fi diagnostics and optimization can be dis-aggregated, with real-time data collection and optimization performed by an agent in the CPE, and long-term data storage and deeper analyses performed by the controller in the CloudCO.

Monitoring, status, performance, test, and diagnostics data are gathered by the Data Collection Function (DCF) from access nodes and other network elements or equipment across the Q-interface, and possibly also from residential gateways across the G-interface. Control and configuration change requests are passed to access nodes across the Q-interface, and possibly

also to residential gateways across the G-interface. A DCF may be called a virtual probe (vProbe), e.g., a probe instantiated in the CloudCO software.

The Analysis and Diagnosis Function (ADF) distills and interprets monitoring and performance data to identify faults, performance problems, and root causes. The ADF can send data and alarms up to the End-to-End Orchestration / OSS, or to the COF.

The COF determines good configurations and sends instructions that re-configure nodes and lines to improve access network performance; this is often called "re-profiling" [BBF TR-197].



The above figure briefly introduces the interactions within the functional architecture for CloudCO Monitoring, Diagnostics, and Optimization. The E2E Service Orchestraton / OSS issues a monitoring, diagnostics and/or optimization service creation request to the CCO Domain Orchestrator (DO), which orchestrates the establishment of appropriate network services using DCF, ADF and COF VNFs. During operation, data is imported from network elements through the Southbound BAA Layer, and configuration may also be sent to network elements and systems through the Southbound BAA layer.

4 Components

Component Framework Name	Component Description
ADF	Analysis and Diagnosis Functions
BAA	Broadband Access Abstraction layer: TR-384, WT-411, WT-413: Aggregates and virtualizes access to DPUs and vOLT PNFs.
CCO DO	TR-384, WT-411
COF	Configuration Optimization Function
DCF	Diagnostics Collection Functions
DPU	Distribution Point Unit: small copper-based Access PNF.
DSLAM	Digital Subscriber Line Access Multiplexer: large copper-based Access PNF.
EMS	Element Management System
MCO	Management Control Orchestration
OLT	Optical Line Terminal: Fiber-based PNF.
OSS	Operations Support System
PON	Passive Optical Network
RG	Premises PNF
SBI	Southbound interface
SDN M&C	SDN Management and Control: TR-384, WT-411, WT-413
VIM	Virtualized Infrastructure Manager:
VNF	Virtual Network Function
VNFM	VNF Manager

5 Actors

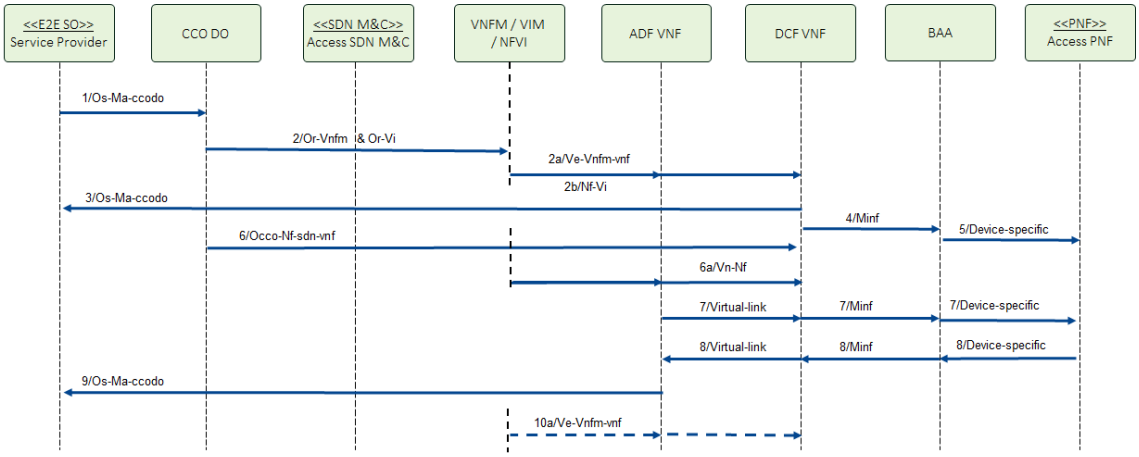
Actor Name	Actor Description	Actions at CCO Perimeter (CCO DO NBI, User action)
Service Provider	The Service provider creates the broadband service, and also creates service users	1. Create service 2. Initiate monitoring, diagnostics, or optimization; and collect responses, via E2E Service Orchestration / OSS.
Service User	Consumer of the broadband service.	1. User connects the Premises PNF (RG) to the network and consumes the service.

6 Interactions

6.1 Interaction 1: Monitoring

Network monitoring repeatedly sends status, performance, and other data from network elements to Service provider's OSS(s). Also, alarms are autonomously sent from the equipment to the OSS(s). This interaction describes in detail how monitoring functions are set-up and run on a CloudCO.

1. CCO DO receives a request for monitoring broadband node(s)/line(s) from external orchestration / OSS.
    a. The request identifies and contains addresses to communicate to relevant equipment, orchestrators, NMS/OSS, and databases.
2. This request is passed from CCO DO to Access SDN M&C
3. CCO DO/Access SDN M&C requests the VIM to instantiate DCF VNF and ADF VNF.
    a. VIM instantiates DCF VNF and ADF VNF.
    b. VIM instantiates and connects virtual network for DCF VNF and ADF VNF.
4. CCO DO/Access SDN M&C provides equipment identification/addresses to the BAA so the BAA can connect to the access equipment.
5. BAA creates Southbound interface(s) (SBI) to the equipment, including legacy and or CCO NETCONF/YANG interfaces. SBIs may include Q-interfaces to access node(s), G-interfaces to RG(s), and management interfaces to aggregation nodes. An SBI may connect through an intermediate system (e.g., an EMS or Persistent Management Agent (PMA)) which may or may not be in the CloudCO.
    a. BAA is now enabled to receive a Northbound API call for a certain action from the DCF and translate this into the proper messages which are sent on its Southbound interface.
6. CCO DO and Access SDN M&C instantiates the Monitoring network service instance by chaining DCF and ADF.
    a. VIM creates virtual link from DCF to ADF.
    b. Alarm thresholds, data types and frequencies for reporting and storage, etc., are determined by the ADF according to defaults and the instructions in the original request 1. from external orchestration/OSS.
7. ADF passes requests for alarm thresholds, data types and frequencies for reporting, etc., to the equipment through the DCF and the BAA
8. DCF collects equipment status, performance and other monitoring data from the equipment through the BAA, and passes it on to the ADF across the virtual link.
9. The ADF analyzes the equipment status and performance data; sends and stores collated data.
    a. The ADF periodically sends sets of collated and analyzed data to the service provider's external orchestration / OSS, and populates the historical database.
    b. The ADF issues alarms to the external orchestration / OSS when appropriate.
10. The monitoring service is terminated when the CCO DO receives a request a request to stop monitoring or is notified of the end of the broadband service.
    a. DCF VNF and ADF VNF may be destroyed or may be retained for future use on this service.



6.2 Interaction 2: Diagnostics

Diagnostics is very similar to Monitoring, except that diagnostics is triggered by a request for data such as request for tests during fault troubleshooting. Due to the similarity, only the differences from Monitoring to Diagnostics are described for this interaction. Steps 8 and 9 may be performed repeatedly.

1. CCO DO receives a request for diagnosing broadband node(s)/line(s) from external orchestration / OSS.

1. The request identifies and contains addresses to communicate to relevant equipment, orchestrators, NMS/OSS, and databases.

2. - 5. Same as Interaction 1: Monitoring

6. CCO DO and Access SDN M&C instantiates the Diagnostics network service instance by chaining DCF and ADF.

1.

   a. VIM creates virtual link from DCF to ADF (same as Interaction 1: Monitoring).

   b. Tests, data to be returned, etc., are determined by the ADF according to defaults and the instructions in the original request 1. from external orchestration/OSS.

2. 7. ADF passes requests for tests, returned data, etc., to the equipment through the DCF and the BAA
   8. DCF collects test results, equipment status, performance and other diagnostics data from the equipment through the BAA, and passes it on to the ADF across the virtual link.

3. 9. The ADF analyzes the equipment test and diagnostics data; sends and stores analyzed data.

   a. The ADF sends a set of collated and analyzed data to the service provider's external orchestration / OSS, and populates the historical database.

4. 10. The diagnostics service is terminated.

   a. DCF VNF and ADF VNF may be destroyed or may be retained for future use on this service.

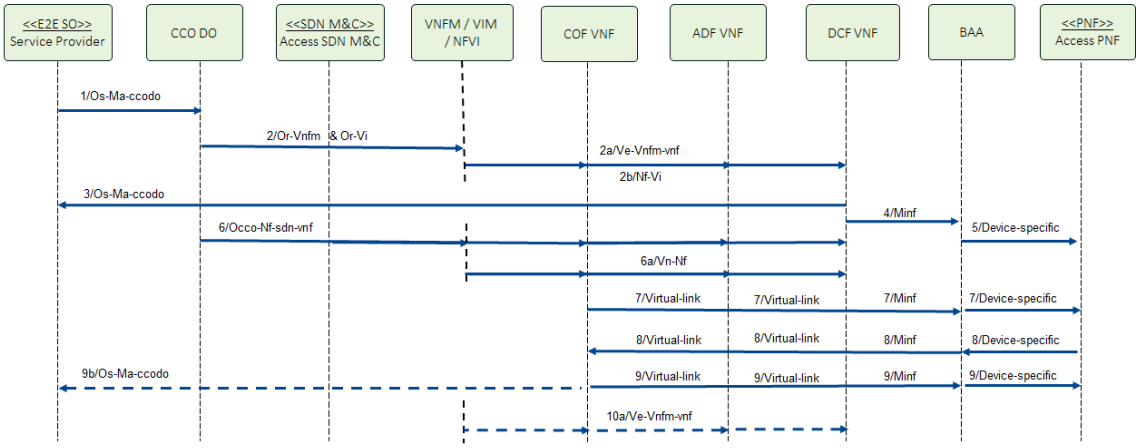
The diagram for diagnostics is the same as Interaction 1: Monitoring.

6.3 Interaction 3: Optimization

Line or network optimization retrieves network data similar to Interaction 1: Monitoring and Interaction 2: Diagnostics. Then, the Configuration Optimization Function (COF) is invoked to configure links and network elements with what should be improved settings. Optimization

may be performed once, e.g., in response to a trouble call; or optimization may be performed periodically or in an iterative fashion during ongoing service delivery. Only a single iteration is described here, however, steps 7, 8 and 9 may be performed repeatedly.

1. CCO DO receives a request for optimizing broadband node(s)/line(s) from external orchestration / OSS.
    a. The request identifies and contains addresses to communicate to relevant equipment, orchestrators, NMS/OSS, and databases.
    b. Can either be a one-time request for a particular line or node, or a request for longer-term optimization of multiple node(s)/line(s).
2. CCO DO/Access SDN M&C requests the VIM to instantiate DCF VNF, ADF VNF and COF VNF.
    a. VNFM instantiates DCF VNF, ADF VNF and COF VNF.
    b. VIM instantiates and connects virtual network for DCF VNF and ADF VNF.
3. DCF queries external orchestration / OSS database for relevant equipment addresses.
4. CCO DO/Access SDN M&C provides equipment identification/addresses to the BAA so the BAA can connect to the access equipment.
5. BAA creates Southbound interface(s) (SBI) to the equipment, including legacy and or CCO NETCONF/YANG interfaces. SBIs may include Q-interfaces to access node(s), G-interfaces to RG(s), and management interfaces to aggregation nodes. An SBI may connect through an intermediate system (e.g., an EMS or Persistent Management Agent (PMA)).
    a. BAA is now enabled to receive a Northbound API call for a certain action from the DCF and translate this into the proper messages which are sent on its Southbound interface.
6. CCO DO and Access SDN M&C instantiates the Optimization network service instance by chaining DCF, ADF and COF.
    a. VIM creates virtual links between DCF and ADF and between ADF and COF.
    b. Requested data to be returned, etc., are determined by the COF according to defaults and the instructions in the original request 1. from external orchestration/OSS.
7. COF passes requests for network state and configuration data to the equipment through the ADF, DCF and BAA.
8. COF imports network state and configuration data from the equipment through the BAA, DCF and ADF.
9. COF analyzes the received network state and configuration data as well as data in the historical database, determines the new optimization configuration(s), writes the new configuration(s) to the equipment through the ADF, DCF and BAA.
    a. The optimization configuration is also stored in the historical database.
    b. The optimization configuration may also be sent to external orchestration / OSS.
10. The optimization service may be terminated, it may be re-run, or it may repeat in the future.
    a. DCF VNF and ADF VNF may be destroyed or may be retained for future use on this service.



7 Success Criteria

Success is defined by speedy and correct implementation and operation of monitoring, diagnostics and optimization functions.

Occasional Incorrect diagnoses or poor optimization of the user's service is not viewed as a failure of the diagnostics and optimization system, a certain amount of such failures are to be expected.

Interaction 1: Monitoring

CCO DO, VNFM and VIM successfully instantiate DCF VNF and ADF VNF.

Network data is successfully imported and analyzed by DCF and ADF.

Periodic collated data and autonomous alarms are successfully sent to the E2E Service Orchestraton / OSS.

Interaction 2: Diagnostics

CCO DO, VNFM and VIM successfully instantiate DCF VNF and ADF VNF.

Network data is successfully imported and analyzed by DCF and ADF.

Analyzed and collated data are successfully sent to the E2E Service Orchestraton / OSS.

Interaction 3: Optimization

CCO DO, VNFM and VIM successfully instantiate DCF VNF, ADF VNF and COF VNF.

Network data is successfully imported and analyzed by DCF, ADF, and COF.

Optimal configurations are successfully sent to the network elements and optionally also copied to the E2E Service Orchestraton / OSS.