WAN Management and Maintenance

Foreword

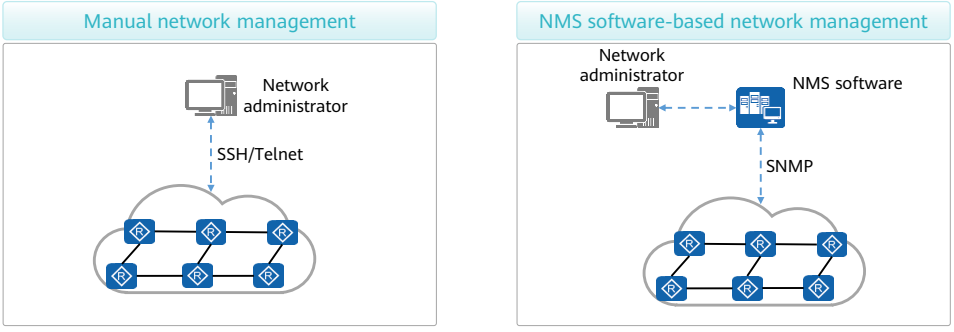
- Network management is the most important task of O&M personnel. Typical management tasks include routine network management, new site deployment, and network troubleshooting. As ICT technologies develop, traditional O&M methods are unable to meet customer requirements because they have the following disadvantages:
  - Routine management is performed based on SNMP using network management software. SNMP, however, is inflexible in the cloud computing era.
  - New site deployment is an exhausting task, which is also challenging, especially when a large number of new sites need to be deployed.
  - Network troubleshooting is challenging for most O&M personnel, and how to systematically troubleshoot faults is also an urgent problem to be addressed.
- This course describes the new protocols and methods for routine maintenance, the methods for quick site deployment, and the methods for systematic network troubleshooting.

Objectives

- Upon completion of this course, you will be able to describe:
  - The disadvantages of the SNMP protocol.
  - How NETCONF flexibly controls devices.
  - The advantages of using telemetry to collect device status and performance data.
  - Northbound RESTful interfaces of the network management system (NMS) and controller.

Traditional Network Management

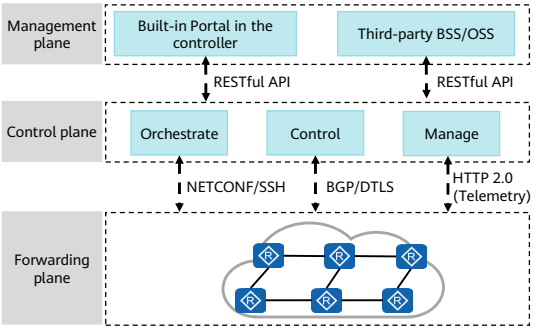
- Network management involves the use of various protocols, tools, applications, and devices to monitor and control network resources, including hardware and software, so as to meet service requirements and network objectives.
- Traditional network management can be performed manually or using NMS software.



- Manual network management is convenient but has the following disadvantages:
  - When managing different types of devices from different vendors, network administrators need to memorize a large number of commands and product features, resulting in high O&M costs.
  - Manual management is inefficient and does not apply to large-scale networks.
  - Problems cannot be quickly located.
- NMS software-based network management has the following advantages over manual management:
  - SNMP can be used to manage different types of devices from different vendors, lowering the requirements for network administrators.
  - NMS software can be used to manage large-scale networks.
  - Faults can be located faster.

Network Management in the Cloud Computing Era

- The advent of the cloud computing era brings great changes in network management requirements, which means network management needs to be performed based on content instead of pipes. Network management in the cloud computing era has the following disadvantages:
  - It is inefficient and complex to manage various types of products from different vendors using NMS software, and automation cannot be implemented.
  - NMS software cannot detect network performance accurately.
- Some new protocols and technologies are developed to solve these problems:
  - The NETCONF protocol simplifies network configuration.
  - Telemetry technology greatly improves the accuracy in network performance measurement.
  - RESTful APIs make network management more open.



Network Management Technologies

- SNMP is the most commonly used network management protocol. It used to be very efficient, but is unable to meet the current management requirements due to the following defects:
  - SNMP cannot configure network devices efficiently and easily.
  - SNMP has a poor performance in real-time network monitoring.
- To address the preceding two problems, the following technologies are developed:
  - NETCONF: It is designed to offer standard device configuration by using the standard YANG data models. Using NETCONF, the controller can efficiently control devices and quickly deliver configurations.
  - Telemetry: SNMP uses the query-response mechanism, so it is inefficient in reporting network status. Telemetry technology uses subscription to improve efficiency in reporting device status.
- In addition, some enterprises have requirements on the openness of NMS software. To meet these requirements, the NMS software or controller provides open northbound RESTful APIs.

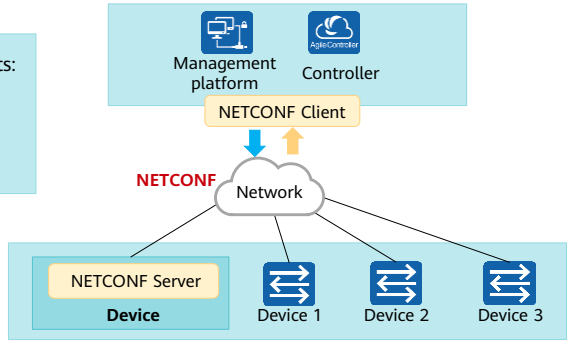
- The reason why SNMP cannot efficiently configure a network is that different vendors have different implementation models for the same type of access devices and the implementation models correspond to different configuration models. As a result, it is difficult to unify standards.
- The reason why SNMP has poor real-time network monitoring performance is that SNMP uses the "query-response" architecture. Frequent queries will cause high CPU usage of network devices.

SNMP | NETCONF | Telemetry | RESTful API

NETCONF Overview

- The Network Configuration Protocol (NETCONF) resolves the difficulty in configuring devices using SNMP.
- NETCONF provides a set of mechanism for managing network devices. To be specific, users can use NETCONF to add, modify, and delete configurations of network devices, as well as obtain the configurations and status of network devices.

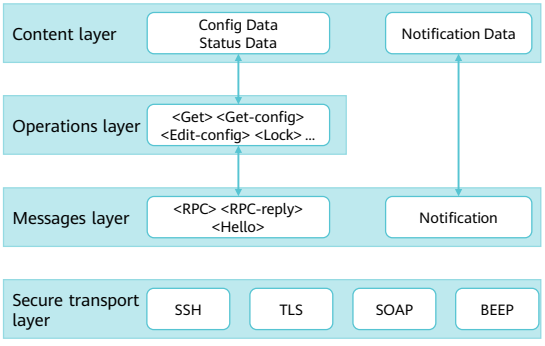
NETCONF has three objects:
- NETCONF client
- NETCONF server
- NETCONF message



- With the development of automated network O&M, automated service deployment, and SDN and NFV technologies, NETCONF and YANG have been considered the basic capabilities of network devices, and also prove to be the best choice for open programming networks.
- NETCONF sessions are carried over SSH and support the heartbeat keepalive and key mechanisms defined by SSH.

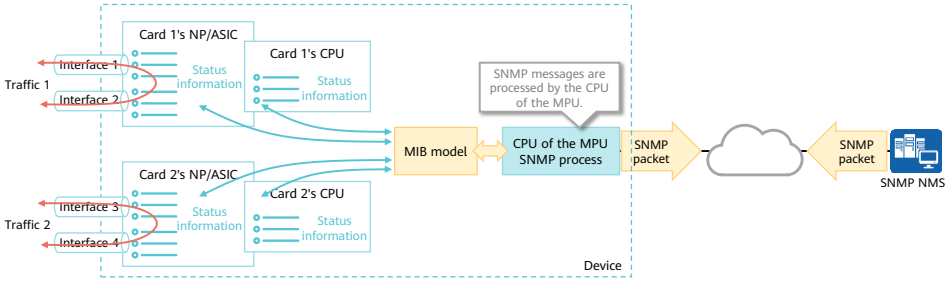
NETCONF Implementation - Protocol Architecture

- NETCONF consists of four layers, which are secure transport layer, messages layer, operations layer, and content layer from bottom to top.
  - The secure transport layer ensures protocol security. Currently, SSH is the most widely used NETCONF secure transport layer protocol.
  - Similar to SNMP, the messages layer provides a mechanism for encoding Remote Procedure Calls (RPCs) and notifications.
  - The operations layer defines the operations for obtaining and editing basic protocol configuration information.
  - The content layer consists of configuration data, status data, and notification data. Data is classified to facilitate cross-device comparison.



Disadvantages of Traditional Network Monitoring

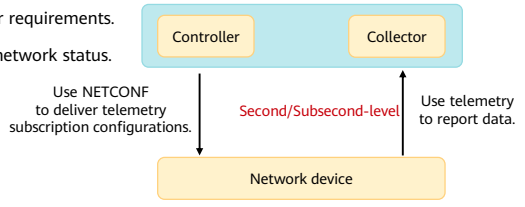
- Traditional network monitoring uses the SNMP protocol to monitor network performance. SNMP obtains network status information in request-response mode. However, when the SNMP NMS requests a large amount of network status information, a large number of SNMP request packets need to be sent, increasing the query time.
- SNMP request and reply packets are processed by the CPU of the device's MPU. Processing a large number of SNMP packets will cause a sharp increase in the CPU usage. On the live network, the smallest SNMP query interval is 5 minutes.
- In the cloud computing era, SNMP cannot meet network performance monitoring requirements.



SNMP | NETCONF | Telemetry | RESTful API

Telemetry Overview

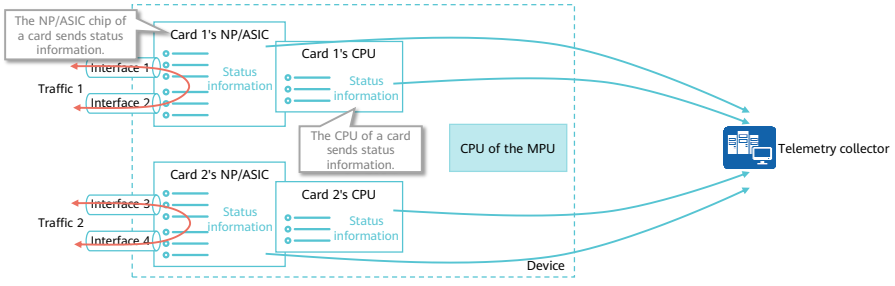
- In the cloud computing era, network status needs to be monitored based on services instead of pipes. In addition, service diversity requires network monitoring to be more flexible.
- Traditional networks use SNMP to monitor network status. However, the interval for reporting network status is too long and therefore the actual network status cannot be collected. Telemetry perfectly addresses the defects of SNMP.
- Telemetry, also known as network telemetry, is a technology for network monitoring, including packet check and analysis, intrusion and attack detection, intelligent data collection, and application performance management. It has the following advantages:
  - Supports multiple implementation modes, meeting diversified user requirements.
  - Collects a wide variety of data with high precision to fully reflect network status.
  - Continuously reports data with only one-time data subscription.
  - Locates faults rapidly and accurately.
  - Leverages big data for data analysis and presentation.



- With the popularization of networks and emergence of new technologies, the network scale is growing, network deployment is increasingly complex, and users have higher requirements on service quality. To meet user requirements, network O&M must be more refined and intelligent. Network O&M are faced with the following challenges:
  - Ultra-large scale: A large number of devices need to be managed and massive amount of information needs to be monitored.
  - Quick fault locating: Users want faults to be located within seconds or even subseconds on complex networks.
  - Refined monitoring: Various types of data needs to be monitored at a finer granularity to reflect the network status completely and accurately. With the monitoring information, possible faults can be predicted, providing a sound foundation for network optimization. Network O&M involves monitoring not only traffic statistics on interfaces, packet loss on each flow, CPU usage, and memory usage, but also the latency and jitter of each flow, latency of each packet on its transmission path, and buffer usage on each device.
- The collector, analyzer, and controller are components of the network management system.
  - The collector receives and stores monitoring data reported by network devices.
  - The analyzer analyzes the monitoring data received by the collector and processes the data, for example, displays the data on the graphical user interface.
  - The controller uses NETCONF to deliver configurations to devices, so as to manage network devices. The controller can deliver configurations to network devices based on the analysis data provided by the analyzer and adjust the forwarding behavior of network devices. It also controls the data that the network devices need to sample and report.

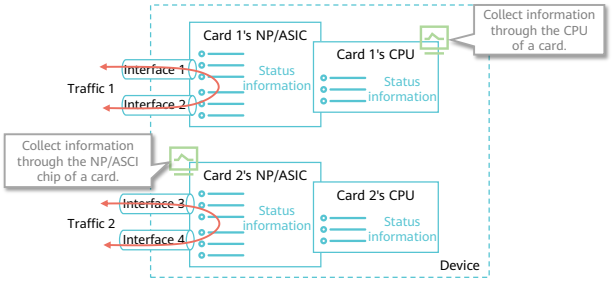
Telemetry Implementation - Distributed Processing

- Telemetry data is no longer processed by the CPU of the MPU. Instead, the device can directly send telemetry data to the collector through the NP/ASIC chip or the CPU of its card. This prevents high CPU usage of the MPU when the device needs to process a large amount of status information.



Telemetry Implementation - Data Collection by Hardware Chips

- Status information can be collected through software using the CPU of a card. In this mode, information can be collected every second.
- Status information can be collected through hardware using the NP/ASIC chip of a card. In this mode, information can be collected every 100 ms.



Quiz

1. (True or False) NETCONF consists of four layers, which are secure transport layer, messages layer, operations layer, and content layer from bottom to top.
   A. True
   B. False
2. (True or False) In telemetry, the CPU of the MPU is used to report device status.
   A. True
   B. False

- 1. A
- 2. B

Section Summary

- SNMP has disadvantages in configuring devices and collecting device status.
- SNMP only supports configuration of each single device. It does not support network-level configuration and cannot implement configuration collaboration among devices, because these are difficult to achieve through programming.
  - NETCONF uses YANG files to translate data into XML language, making network configuration more convenient and flexible.
- The interval at which SNMP collects device status is long, and device status collection causes the CPU usage of the MPU to increase.
  - Telemetry reports device status through subscription, and device status is no longer reported through the CPU of the MPU, reducing the CPU usage of the MPU.
- In the cloud computing era, standards-compliant NBIs need to be developed for the NMS/controller. The HTTP2.0-based RESTful API is a standard open interface that can use HTTP packets to connect to the NMS/controller, simplifying control.

Summary

- In the cloud computing era, SNMP is no longer suitable for managing large-scale networks due to its disadvantages in configuration and status collection functions. The NETCONF protocol and telemetry technology are developed to solve these problems. NETCONF facilitates device configuration on the NMS and controller, whereas telemetry technology accelerates device status collection.