IMAGINE THE POSSIBILITIES...
Streaming Telemetry Data from the Home Network using OpenWrt Access CPE

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Outline for Streaming Telemetry Data from the Home Network using OpenWrt CPE

Presentation Topics:

• Introduction
• Home Network Architecture
• Access CPE OpenWrt Software Architecture
• Access CPE OpenSync Software Architecture
• Streaming Telemetry Data Path
• Grafana Dashboard Design
• Comparison with Other Telemetry Methods
• Conclusion
Introduction

• Home networks have become more complicated due to explosion of different types of wirelessly connected devices such as smart IoTs, cell phone, gaming devices, tablets, and laptops.

• Cable operators typically have limited or no information about the access CPE health status, and customer’s home network

- IoT is M2M communications
- IoT Growth is staggering:
  Today, it appears almost exponential
  Tomorrow we’ll see new IoT applications
- U.S. smart home market is expected to show CAGR of 15.8% by 2025.

U.S. Projected Smart Home Growth Rate Forecast

Source: satista.com
Home Network Architecture

• **Configuration A** – Some MSOs use a two-box solution to offer Broadband service (CM + Wi-Fi router)
  • Software stack is monolithic customized for each Silicon and OEM vendors
  • No information on the wirelessly connected clients (# of clients, type of clients, traffic)

• **Configuration B** – Significant benefits compared with Configuration A
  • Agile software stack
  • D3.1 eMTA with routing functionality
  • Cost optimized Wi-Fi APs
  • Cloud-based infrastructure for:
    • Command/control
    • Streaming telemetry data
OpenWrt-based software stack integrated with:

- OpenSync™ layer
- Silicon vendor SDK
- Smart agent
OpenSync™ cloud composed of NOC and controller for managing a network of OpenSync™-enabled devices

OpenSync™ cloud provides operator-friendly services:
- Device and firmware management
- Inventory and billing system
- Onboarding and provisioning of field-deployed devices
- Telemetry reporting
- Network operations & customer support

Access CPE OpenSync™ Software Architecture

OpenWrt Collectd

Si Vendor SDK

OpenWrt Kernel

Hardware Layer

OpenSync™ Controller services

OpenSync Cloud Command/Control services:
- Provide Network status
- Display IP address
- Network mask
- DNS server address
- DHCP status
- Parental controls
- Speed Test initiation and results

Command/Control + Telemetry Data + Speed Test Initiation
OpenWrt-based Smart Agent Components

**usCeMTA**: Pull all the DOCSIS upstream channel information used by the D3.1 eMTA (RF level, channel frequency, etc.).

**dsCeMTA**: Pull all the DOCSIS downstream channel information used by the D3.1 eMTA (RF level, channel frequency, etc.).

**latClient**: Measures and reports the round-trip latency from the D3.1 eMTA to each of the wirelessly connected devices in the home network based on their IP address or MAC address.

**connClient**: Measures and reports the number of transmitted and received packets from each of the wirelessly connected devices in the home network.

**specAnalyzer**: Obtain the RF downstream and upstream spectrum of the Access CPE device.

**eMTALat**: Measures and reports the minimum, maximum, and average round-trip DOCSIS latency between the D3.1 eMTA and the connected CMTS.

**Write_ctm**: Collects various statistics from the device for aggregation and forwarding to a desired destination. Converts them to Protobuf format, and sends the collected telemetry data to the OpenSync™ STATS Manager (SM).
  - SM forwards the collected telemetry data to the OpenSync™ Queue Manager (QM).
  - The QM sends the collected telemetry data to the cable MSO’s Streaming and Analytics platform via the MQTT server.
## OpenSync™ Managers’ Functionality and Status

<table>
<thead>
<tr>
<th>Manager Name</th>
<th>Manager Functionality</th>
<th>Manager Status</th>
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<tbody>
<tr>
<td>Diagnostics Manager (DM)</td>
<td>Responsible for processing all requested wired and wireless statistics and sending results to the cloud. The configuration is done through OVSDB while MQTT is used for the data plane. All the telemetry health metrics mentioned below are collected by write_ctm component as shown in Figure 2, and are transmitted to the SM, which forwards all the collected telemetry data to the QM as shown in Figure 3.</td>
<td>Required for basic operation</td>
</tr>
<tr>
<td>Connection Manager (CM)</td>
<td>Responsible for establishing the backhaul connection and keeping connectivity to the cloud.</td>
<td>Required for basic operation</td>
</tr>
<tr>
<td>Network Manager (NM)</td>
<td>Responsible for managing all network related configuration and network status reporting.</td>
<td>Required for basic system network configuration</td>
</tr>
<tr>
<td>Wireless Manager</td>
<td>Not applicable to access CPE devices. Used in Wi-Fi routers to read and updated their configuration and state tables.</td>
<td>Required for basic system network configuration</td>
</tr>
<tr>
<td>Queue Manager (QM)</td>
<td>Responsible for aggregating reports from different OpenSync™ Managers</td>
<td>Optional</td>
</tr>
<tr>
<td>Statistics Manager (SM)</td>
<td>Responsible for spawning the rest of the OpenSync™ managers and optionally monitoring them. The iPerf speed test software was developed and integrated into the DM such that the speed test can be initiated from the OpenSync™ NOC, and the DS/US speed test results are sent to Grafana dashboard.</td>
<td>Optional</td>
</tr>
<tr>
<td>OpenFlow Manager (OM)</td>
<td>If the OpenVSwitch is used on the device, then the OM is responsible for managing packet flow rules.</td>
<td>Optional</td>
</tr>
<tr>
<td>Log Manager (LM)</td>
<td>Responsible for collecting and uploading logs and system information upon the Cloud request (logpull) and for handling log severity setting for running modules.</td>
<td>Optional</td>
</tr>
<tr>
<td>Platform Manager (PM)</td>
<td>Responsible for covering specific platform features which can’t be covered by other managers such as synchronization between device GUI and cloud, and cloud-managed device parental control.</td>
<td>Optional</td>
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Streaming Telemetry Data Path

- Operators Streaming and Analytics platform architecture separates the control and data planes
- Data plane includes Cog platform, Data Distribution Bus (DDB), and Data Governance platform
- DDB is initial point of data ingestion driven by Apache Kafka
- Data governance provides the framework for decisions and accountabilities within the corporate structure to manage and protect the data assets.

Telemetry data is ingested by different data analytics tools.
Grafana Dashboard Design

- Design goal - concisely present all the different types of telemetry data to the Cable operator’s care agent
  - focus the agent attention to any reported failures and unhealthy device metrics
- Organized hierarchical color-coded Grafana dashboard with the key components (level 1 health metrics)
- Level 1 metrics consists of a group of metrics with common function
- Level 1 operational status based on pre-determined threshold levels.
Grafana Dashboard Design (continue)

- Level 2 metrics shows the status of each of the reported metrics in Level 1 group such as D3.1 eMTA system or home network traffic. For example,
  - CPU utilization < 75% color-coded Green (7.68% in example below)
  - CPU utilization ≥ 75% but ≤ 85% color-coded Yellow
  - CPU utilization > 85% color-coded Red
- Level 3 metrics shows the selected metric vs. time behavior based on the selected time interval (one hour)
- Machine Learning (ML) models can be executed on the selected metrics based on historical data to identify patterns and predict unhealthy device behavior.

Reported CPE Utilization (%) vs. time (Level 3)
The actual client’s identification can be displayed on the Grafana dashboard with the integration of a device fingerprinting agent such as a Cujo Artificial Intelligence (AI) agent.

Benefits:
- Identify if there is specific client that consumes most of the bw in the home network
- Make changes to the HN

Home network traffic parameters for the wirelessly connected clients (Level 2)
Grafana Dashboard Design (continue)

Example of Downstream Channel Information

**Benefits:**
Having access to monitored historical data with ML models can significantly help to identify troubled CMs in the field compared with other CMs connected to the same CMTS.
## Comparison with Other Streaming Methods

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<th>Streaming Telemetry Method</th>
<th>Pros</th>
<th>Cons</th>
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| Internet Protocol Detail Record Streaming Protocol (IPDR/SP) | • Used by CMTS via CableLabs-defined schemas (SAMIS Type 1) to collect specific CM and service flows’ attributes every 15 min.  
• Standardized methods used by operators | • Limited telemetry data is collected by the CMTS  
• CMTS doesn’t make decisions on the collected data  
• Expanding the CMTS usage of IPDR/SP to collect other metrics would overburden the CMTS  
• New IPDR schemas for non-DOCSIS parameters are not defined |
| Model-Driven Telemetry (MDT)                       | • YANG data models are being by CableLabs                           | • New access CPE software layer needs to be defined to support YANG data models  
• No performance vs. cost analysis has been done to justify MDT-based development |
| OpenWrt & OpenSync™ software                       | • Open-source agile software stack with customized plugins  
• Agile lightweight and efficient smart agent  
• Doesn’t burden the CMTS  
• Easily ported to different OEM vendor platforms | • Non-standardized method  
• Have not been deployed |
Conclusions

• Agile OpenWrt software stack integrated with OpenSync™ layer and Silicon vendor SDK with IPv4/IPv6 routing functionality was developed on common existing access CPE HW
• OpenSync™ cloud connectivity provides a standardized command/control for networking devices as well as operator-friendly services
• Smart lightweight and efficient agent was developed to enable the access CPE to stream various types of metrics to the operator’s Streaming and Analytics platform
• Hierarchical color-coded Grafana dashboard was developed to display wide variety of telemetry data
• Comparison with both IPDR/SP and MDT methods reveals the challenges with the implementation of these methods on access CPE devices
• Adoption of an OpenWrt-based streaming telemetry offers clear benefits to Cable operators:
  • Direct streaming of telemetry data to the cable MSO’s Streaming and Analytics platform via the OpenSync™ cloud w/o overburdening the CMTS
  • Enhance customer satisfaction by reducing the number of truck rolls as field issues are resolved more quickly
  • Standardized the OpenWrt-based software architecture is expected to accelerate the development and deployment of new revenue-generating services
Thank You!

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