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Deriving Insights: The Reference Design Kit (RDK)

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Deriving Insights:
The Reference Design Kit (RDK)

As the telecommunications industry continues to migrate towards both open source and cloud-driven platforms, major cable providers are taking note. Cable companies are moving rapidly to integrate open source software stacks for both television set top boxes (STB) and wireless gateways – the boxes combining both the cable modem and wireless access point (AP). Millions of CPE devices are already deployed in the field, with more than 250 global licensees provisioned. Major manufacturers of this customer-premises hardware are also supporting the trend. And multiple cable operators—including Comcast, Charter Communications and Liberty Global—have also embraced the Reference Design Kit (RDK), the pre-integrated software stack that provides a common framework for powering this customer-premises equipment.

Historically, it has taken up to two years to develop a new cable set-top box, measuring from the design stage to delivery to a customer’s home. Deep investigation and troubleshooting of wireless gateways were formerly limited to those members of the manufacturer’s software team who were evaluating and managing the firmware. Cable operators have typically had only limited visibility into this development process, given that they usually have not had access either to the code or to instrumentation frameworks.

By contrast, the RDK software stack now enables cable companies to access and manage the code themselves. By enabling these companies to manage new features and bug fixes, the RDK can reduce troubleshooting time from weeks and months to hours and days, while increasing the velocity of releases. By taking control of the code, operators can also manage the wireless gateway portal in order to deliver a consistent experience across the various hardware vendors. All of these advantages are particularly beneficial in today’s competitive market, where agility and efficiency are rewarded.
What is RDK?

Conceptually, RDK is a standardized software stack with both video (RDK-V) and broadband (RDK-B) iterations. This type of architecture allows the device software to be controlled by the operator, while increasing the speed with which new features and technologies are developed and adopted. RDK firmware can also be deployed to devices that are already installed in the customer's home or business.

From a code base standpoint, RDK management is handled by a third party who ingests, tests, and monitors the continuous cycle of code development. Using an open-source approach, both RDK-V and RDK-B code are made available to users through the Apache 2.0 license at no cost. Companies who are members of the RDK community or executed CLA can contribute software changes and enhancements to either of these RDK stacks. RDK code management also offers the operator the opportunity to build out private functions that historically are available to only the specific communications provider.

This code management structure is a key element of the open-source process. It furnishes communications providers with complete perspective on all the RDK components, as well as access to test and check-in their code. It also provides operators with the ability to take advantage of continuous code iterative capabilities from the open source community.
The Reference Design Kit for Video (RDK-V)

The RDK-V software stack gives communication providers a common framework for developing STB software. It incorporates functions such as tuning, IP video, and media streaming/DLNA, but still allows for user interface (UI) control and development by the operator. The momentum around RDK-V continues to grow, and support for the stack is currently offered by over 250 companies, including SoC vendors, software developers, system integrators and network operators.

As displayed in Figure 1, the Multichannel Video Programming Distributor (MVPD) platform components include modules such as User Navigation and Third Party Apps that sit on top of the RDK stack. The RDK stack itself is built on top of an industry standard Linux 2.6 kernel. A central portion of the RDK stack is the RDK Media Framework (RMF). The RMF is a robust, full-featured framework for the development and delivery of media services within the home networking environment. RMF provides the developer with an easy-to-use, powerful set of objects that can be combined to stream media and play back within the home.

It is important to note that an operator may not simply download the RDK stack and implement it as a turnkey solution. Although implementation for the generic RDK components is included, some of the components within RDK are only frameworks for implementing features, and the actual implementation, which is often customized for an operator, is not included. Every operator needs to integrate not only the MVPD components, but also their own security, back office systems, and unique business rules.
Figure 1 - Reference Design Kit Stack – Video (RDK-V)

MVPD

User Navigation

3rd Party Apps

App Manager

RDX

Service Manager

DLNA/Digital Media Server

DLNA/Digital Media Streamer

Media Player

Media Recorder

CA/Network Components

RDX Media Framework (RMF)

S/W Download - HTTP/TFTP

Service Manager

Closed Captioning

Copy Protection (DRM)

HTML Diagnostics

Webkit

Qt

GStreamer

Resource Management Framework

TR-069/ SNMP Remote Management

Event Logs

RDX-Based Linux Distribution

SOC

OEM

MVPD Selected

RDX Components (Additional)

Open Source

Third Party Components
The Reference Design Kit for Broadband (RDK-B)

Similar to RDK-V, RDK-B is a standardized software stack that provides a common method to manage complex functions. Functions include wide and local area networking (WLAN/LAN), diagnostics, and networking interfaces such as Wi-Fi. Operators can apply the architecture to several different device types, including both home and business wireless gateways, MoCA-based modules, Wi-Fi extenders, and Internet of Things (IoT) controllers.

Goals of RDK-B include creating a standardized IP endpoint and platform to which companies can develop code. Both Arris Group Inc. and Technicolor/Cisco Systems Inc. have contributed code to the RDK-B stack, with Arris deploying its TG1682 gateway with RDK-B software included. From a timing standpoint, it may make sense to deploy RDK-B, since DOCSIS 3.1 is also arriving, and changes at the equipment level may also occur simultaneously.

The RDK-B framework provides basic component management and message distribution, while supporting plug-in component modules. The Linux D-Bus in RDK-B is a central point where applications can send and listen to signals and conduct method calls, while extending a common architecture across CPUs. The Component Registry is a centralized database of registered components and services, which supports multiple management protocols and data models, such as SNMP and TR-069 with TR-181. RDK-B also supports the Internet of Things (IoT) protocols and connectors such as ZigBee HA 1.2 Hub, Bluetooth LE, and AllJoyn/OIC Connectors.
Figure 2- Reference Design Kit Stack – Broadband (RDK-B)

DOCSIS CM

MTA

ACS

SNMP MGT

WEB Browser

SSH

HNAP MGT

Xfinity Home

CM Agent

MTA Agent

TR-69 PA

SNMP PA

WEB UI PA

CU Tools

HNAP PA

WEJB Support

iControl Security

Reboot Manager

Component Registry

Persistent Storage Manager

Test & Diagnostics

LAN Manager Lite

Core Provisioning & Management
TR-181 Data Model

WIFI Provisioning & Management
TR-181 Data Model

MoCo Provisioning & Management
TR-181 Data Model

WIFI Abstraction Layer

MoCo Abstraction Layer

WIFI Drivers

MoCo Drivers

Open Source:
- IPV4/IPV6
- DHCPv4/5
- IP Route/IP Tables
- DS Lite
- Prefix Delegation
- Bridge Utilities
- VLAN
- Wireless and MLS proxy
- DNS Proxy
- RIP
- UPNP IGD
The more insightful shift in analytics is recognized as the user moves into the advanced analytics realm of Diagnostic Analytics. This second step includes deeper root cause analysis – going beyond single variate correlation into multi-variante analysis to determine and recognize that many issues are not driven by a single event or error, but multiple contributing factors. This second step may also include enriching existing data with additional obtainable data sources and can provide an improved

Figure 3 – Analytics Roadmap
perspective on the core data sources by enabling operators to observe deeper comparisons and correlations.

As the user enters Predictive Analytics – Step 3 – the user leverages historical data and transforms it into a look into the potential future with forecasting. These steps include building analytic models at the lowest levels of the business and looks for predictable behaviors, propensities, and business rules that can be used to predict the likelihood of certain behaviors and actions – helping to answer the question “What will happen?”

Prescriptive Analytics assists in directing the user towards what actions should be taken next by leveraging the findings from the first three steps and applying additional logic and rules based on both user and machine learning. It improves the speed and quality of decision making to confirm that analytic-enabled insights are turned into both actions and measurable outcomes that drive higher performance. Techniques such as Monte Carlo simulation and non-linear optimization can be used to help model the probability of different outcomes while including factors such as risk and uncertainty.

By intertwining data available within RDK, data aggregation, and advanced analytics, the user can quickly move beyond basic reporting and trending. Applying concepts of data science will drive the user past the zone of descriptive analytics towards both diagnostic and predictive analytics. The user can apply logic, business rules, algorithms, statistical models, and analysis alongside industry-focused management consulting methods in order to develop specific insights.
Accenture Solution
Accenture has developed a Tableau-based visualization framework with a mySQL database supporting the backend data infrastructure. The solution includes daily ingestion of all data sources into mySQL DB for aggregation and data transformation. The RDK-B open software stack enables operator control of the device software and the ability to pull metrics/status from the wireless gateway, such as crash and usage logs on a per firmware release basis. By integrating additional data sources, such as trouble ticket and truck roll data, operators can start to understand the end-user experience based on firmware releases (CARE tickets). Ingestion of other metrics, such as network cabling health, can help filter out end-users that may have HSD issues from sources other than the RDK-B firmware.

Key capabilities include:

- Filtering out events where RF metrics are poor and suboptimal performance is not attributable to RDK-B firmware
- Correlating RF metrics, ticket logs, and RDK-B crash data to filter out high-impact incidents where firmware could be the potential root cause
- Combining RDK-B information such as reboot, crash, and CPU data to create a Device Analytical Record (DAR) to optimize firmware development and deployment
- Providing email notification or executing a script based on specific alert thresholds, such as trouble ticket count or firmware crashes
- Potential use case development for predictive analytics to anticipate future high-impact incidents and predict future trouble ticket counts

By leveraging analytics and broadband metrics available via RDK-B, the engineering team can understand the end-user experience after a firmware release. The team can also prioritize JIRA software development backlog, such as defects, based on both QA and RDK-B Dashboard feedback, including the number of calls and tickets received based on a specific error. By prioritizing these issues, the provider can tackle bugs that are driving the overall cost of customer care. Additional business outcomes include a reduction in RDK-B-related trouble tickets since implementation, and a reduction in troubleshooting analysis time.
Opportunities – Analytics

The combination of an open source software stack, such as RDK, and the application of analytics derives several different types of use cases that can immediately be applied to a user’s ecosystem.

Use Case: Understanding and Improving the Customer Experience

RDK presents a unique opportunity for communications providers on several fronts. The code base comes with a large amount of machine data out of the box such as errors, reboot, crash, CPU, and system memory. Also, since operators control the code, they can extract visibility and instrumentation based on the exact things in which they are interested. While requesting a new metric or field from an OEM could take six to 12 months, RDK enables firmware releases with the necessary visibility and instrumented code in mere days or weeks. In addition, RDK can go beyond a standard TR-069 connection to provide data via new connections such as sockets, thereby allowing for orders of magnitude of improvement in the quantity and/or frequency of data reception.

Operators can address engineering and business challenges by employing reporting, visualization, and analytics for high-speed data (HSD) offerings. An example of an end goal might be to drive down the number of trouble tickets from RDK-B wireless gateway users and provide an optimum HSD user experience.

Use Case: Operations – Root Cause Analysis

Often it is not simply one variable that pushes a customer to contact a support team. Multi-variate analysis is critical to providing deeper insight into the root causes of an issue. Variables should include not only RDK log data—such as crashes, reboots, and errors—but also other data sources such as network status, customer interactions with the device, ticket history, and user type.

By identifying not only the variables that correlate to tickets but also their relative importance, advanced analytics can help providers target issues by priority. Figure 4 indicates the positive

Figure 4 – Significant Variables – Correlation
or negative correlation between errors and trouble ticket reports. In the sample data, the positive figure in CPU signifies that the presence of this variable is linked to the likelihood of a produced trouble ticket. Additional analysis can be developed to determine and sort the significant predictors from the model by their relative importance in explaining the target variable. By establishing multi-variate root causation, the user can pinpoint the key contributing factors that led to the customer trouble ticket. Potential outcomes could include a reduction in trouble tickets and an enhancement of product stability.

**Use Case: Ticket Prediction**

By parlaying the root cause analysis findings, the user can leverage incident prediction—that is, the probability of a device raising a ticket. After developing a model with a certain level of confidence, ticket probability could be established for specific groups or users, or down to the device level.

The appropriate engineering team could proactively leverage this information through a maintenance window reboot, or a forced firmware upgrade to alleviate known issues. In effect, the team would thereby minimize the chance of another costly customer support center call, and increase the likelihood of problem resolution before the customer recognizes a potential issue.

Operations optimization, such as call center staffing and rationalization, is another example of how providers could leverage ticket prediction. By aligning engineering and operations planning, care centers can properly prepare for not only the call rate to be expected after a new firmware release, but also the types of issues the customer could expect. Training guides and call center scripts could be updated so that the customers who do end up calling the care center can have potentially faster resolution rates and lower call times—improvements that both the customer and the operator will value highly.

**Figure 5 – Model Equation and Probability Matrix**

<table>
<thead>
<tr>
<th>MAC3</th>
<th>CPU</th>
<th>RDKB</th>
<th>Ticket Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>123E5A21EC3A</td>
<td>1</td>
<td>71</td>
<td>0.86</td>
</tr>
<tr>
<td>123E5A21ECCB</td>
<td>0</td>
<td>13</td>
<td>0.43</td>
</tr>
<tr>
<td>123E5A21ED0C</td>
<td>0</td>
<td>0</td>
<td>0.11</td>
</tr>
<tr>
<td>123E5A21ED1D</td>
<td>0</td>
<td>5</td>
<td>0.62</td>
</tr>
<tr>
<td>123E5A21EDEAE</td>
<td>1</td>
<td>25</td>
<td>0.46</td>
</tr>
</tbody>
</table>
Figure 6 - Predictive Sample
**Use Case: Product Development and Management**

In the case of cable providers, it is not uncommon for a provider to have more than one manufacturer providing wireless gateways or set-top boxes. An open-source software structure combined with analytics can guide product managers to attainment of a higher level of customer satisfaction. By ingesting and tracking key metrics, the provider can achieve specific outcomes that support product development:

1. **Understanding User Behavior**: Usage of specific aspects of the device, including how often an application is triggered, how much time is spent on the device, and the types of errors and reboots that occur on the device, are all relevant examples that should be examined and measured.

2. **User Satisfaction**: Tracking the number of tickets reported, the number of truck rolls regarding specific users or groups of users, and the number of tickets reported per firmware, can provide insight into overall customer satisfaction.

3. **Customer Segmentation**: Leveraging the data to understand where your customers are using the service, and any associated demographic information, may help target not only a better product, but also sharper customer service.

4. **Manufacturer Analysis**: Comparing and contrasting the performance of each provider or manufacturer based on trouble tickets, errors occurred, and performance metrics such as crashes, can be quickly presented to the provider in order to enhance existing offerings and products.
Conclusion: Why Leverage RDK

The concepts of open source software, data aggregation, and analytics are not exclusive to RDK-B. These same concepts can be applied to any dataset where enough information is provided to enable statistical significance. For example, platforms such as RDK-V, RDK-C, and IoT could also benefit from this framework. The combination of RDK-B and analytics can also help providers to reduce trouble tickets and properly staff their call centers. When descriptive analytics can be combined with advanced analytics, operators can further improve the customer experience at the level of both the device and its support, while optimizing operations expenditures and improving product development. The open-source software stack will afford accessibility to the provider’s devices, and opportunity to apply analytics in order to maximize insights which will lead to specific business outcomes.
About the Authors

Ragnar-Miguel Myhrer is a Managing Director with Accenture, where he leads the North America Network Practice. He can be reached at ragnar-miguel.myhrer@accenture.com.

Ryan Ray is a Technology Consulting Manager within Accenture’s Network practice. He can be reached at ryan.ray@accenture.com.

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