RDK All Access (Networks): DOCSIS, DSL, PON and Beyond

How Industry Consolidation Created a Need to Support Multiple “Last Mile” Topologies

A Technical Paper prepared for SCTE•ISBE by

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Table of Contents

List of Figures

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Introduction

Global service providers are no longer tied to a single type of access network – DOCSIS, DSL, Ethernet, or EPON/GPON. Decades of consolidation resulted in a patchwork of last mile access, which necessitated adaptability – in the plant and in CPE (Customer Premises Equipment.) CPE built upon the Reference Design Kit (RDK) began with access networks linked via DOCSIS (Data Over Cable Service Interface Specification), and is evolving to be able to connect over a wide and growing fabric of access network types, from DSL (Digital Subscriber Line), typically used in telco plant, to Passive Optical Networks (PONs) used in enterprise environments.

As multiple access networks become the norm, a need arose for a common and unified software environment, so as to simplify network operations and optimize feature utilization, regardless of underlying network specifics. An advanced suite of WiFi security features, for instance, should be able to be added into a service suite, simultaneously and seamlessly across DOCSIS, DSL, and PON topologies. That common and unified software environment is the RDK (Reference Design Kit) broadband profile, designated in this paper as “RDK-B.”

With a common and extensible broadband software stack, operators can design their product roadmaps beyond the “speed wars,” historically relevant but arguably moot now, with the expansion of Gigabit-grade connections. Featur development can focus on how to bring additional value to devices connected to the access network (again, regardless of last mile type), to differentiate the customer experience.

This paper overviews access network types and related abstraction layers within the RDK/Broadband stack to support them.

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1. The RDK Community

The RDK community now includes 400+ contributing members, ranging from silicon providers to OEMs (Original Equipment Manufacturers) to systems integrators, and service providers.

From the perspective of an active OEM in the RDK community, and reflective of the consolidating nature of the cable and telecommunications sector, our involvement requires a bit of background. Briefly: Cisco, through its 2003 acquisition of Linksys, inherited and subsequently developed the broadband router software stack, internally called "CCSP," which became and remains a core component of the RDK profile used in broadband gateways. Technicolor acquired Cisco's Connected Devices division in 2015, and continues to "vote with code," in terms of ongoing, open source contributions to the core RDK stacks for video, broadband, and IoT/connected devices. Specific to the CCSP stack, we open sourced it and added operator-requested components. In parallel, we built the RDK stack into all gateways capable of running in DOCSIS (3.0) environments; by the middle of 2016, RDK was running on close to an estimated 7 million broadband gateways, worldwide.

The latest DOCSIS version, 3.1, was fielded onto RDK broadband gateways in mid-2017, and that code base was open sourced to the RDK community last year. We estimate that RDK's broadband profile is running on more than 70% of the world's D3.1-based gateways, and continues to advance with operator-relevant features and updates, distributed in a far more agile cadence than previously possible.

2. RDK and Open Source

The RDK code base and community are shepherded by RDK Management LLC, headquartered in Philadelphia with core engineering resources in Silicon Valley, Europe (Ireland and the Netherlands), and India. RDKM manages a growing community comprised of more than 400 technology companies, worldwide, with thousands of engineers working on RDK contributions on a daily basis.

RDK operates as an open source project. Its core activities include strategy, roadmap and code releases; tools development and testing; training/technical collaboration; and community events, like this session at the 2019 SCTE Cable-Tec Expo.

Members within the RDK operate along a core set of principles:

- It's free to join / membership is via a royalty-free/$0 license
- Development happens in the open
- Leverage community tools and testing wherever possible
- Expect a regular cadence of useful releases
- Contribute and pull from a globally-developed code base
- Operate at a pace that defines product velocity.

The RDK stack used in broadband gateways and routers is 100% open-source, via a royalty-free Apache license. It is designed to be extensible, in that members can bring in other open source software components as desired.

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3. Why Global Service Providers Favor RDK

At its core, and from its onset, RDK is designed by operators, for operators. As such, it provides an unprecedented amount of technological and strategic freedom, in that operators have direct control over the source code, and can determine the directions they want to go with software and the features important to video and broadband services. The risk of "getting bricked" because of a code or other change, higher up in the chain of command, is nil. Because it was designed by and for operators, RDK stacks are precision-tuned for advanced device management, real-time feature control, device telemetry, and secure code downloads, across all profiles, for all (RDK-based) devices in a home.

One element unique to RDK and the operator community is its tight alignment with System on a Chip (SoC) providers[1]. Prior to RDK, for instance, operators rarely collaborated with silicon providers, working instead with set-top and gateway OEMs who would, in turn, laisse with the chip providers. Those "waterfall"-styled development timeframes were, in fact, a major driver for RDK's existence in the first place: It used to take as long as three years (and longer), from the time an operator had a concept for a new piece of CPE, to the time that set-top or gateway went into consuming homes. By aligning with SoC providers, operators gain device velocity, as well as full visibility into the RDK stack, which is vital to troubleshooting, triage and optimization.

While RDK began as a video-focused initiative, it has since expanded to become a whole home software platform to manage all devices – video, broadband, and the IoT / connected devices. That's in large measure because of the driving competitive need to move quickly in both existing and new service domains: Video was first, quickly followed by broadband, and after that the landscape of IP-connected devices from the IoT and elsewhere. One of the comments we hear routinely, as a provider of RDK-based CPE, is that RDK enables service/feature agility for the whole home, with a depth and range of telemetry data that enables related business segments to move more quickly and adeptly, from customer care to field operations and proactive network management.

4. The RDK Deployment Process

The current process for the RDK stack, in terms of how features and fixes are identified and released, is depicted in Figure 1. From left to right -- from concept to deployment -- operators and vendors develop, test, field-trial, and launch, around the clock, and across more than 400 partners. On the left, a product plan is identified, informed in part by an architectural forum, and RDK feature backlog list, and community contributions. The plan-of-record is developed by the architectural forum, which decides the inclusions for the next release. This is somewhat of a fine art – putting in too many elements can cause delays, yet there's always more than enough to go into a release.

Once the selected enhancements or fixes are selected, development occurs – operator A may take one element, and vendor B the next, in terms of coding for features and improvements. Field deployment typically consist of regression, security and stability testing.

RDKM manages the process, from license scans to code contributions, continuous integration testing, and build verification. RDK releases are dropped both iteratively (as needed) and quarterly (recurring). A typical quarterly release for RDK-based broadband devices contains roughly 50 "user stories," which is the lingo of feature enhancements, and 100 fixes/improvements.

[1] Broadcom, Intel, Qualcomm and Quantenna, among others.

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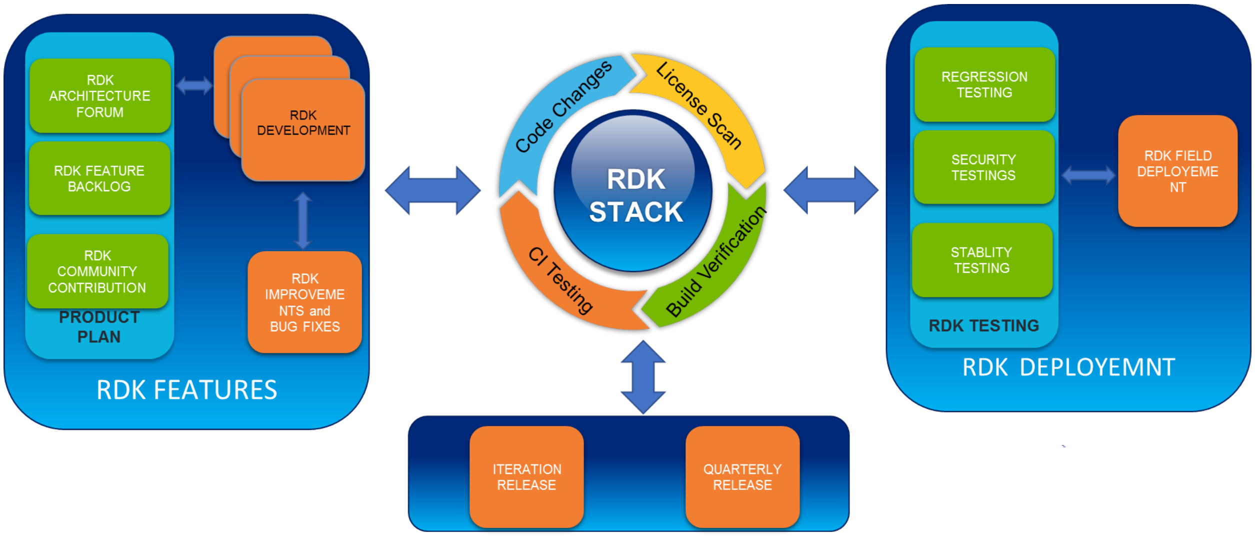

Figure 1: RDK Feature and Deployment Process

5. The RDK Broadband Architecture

Figure 2 depicts the architecture for the RDK Broadband profile. As can be seen, the stack is entirely based on Linux, with a common message bus (DBUS/RBUS), important for registering attached components, like cable modems, EMTAs (Embedded Multimedia Terminal Adaptors, WiFi Access Points/APs, and Ethernet, MoCA (Multimedia over Coax), and IoT devices, such as through Zigbee.

Hardware Abstraction Layers, or HALs, accompany each RDK device type, and specify the functionality that the SoC needs to provide in its SDK. This means that RDK defines the HAL or header files, and the silicon providers implement the HAL in their SDK. RDK's broadband profile defines the functions to speak to each agent. For instance, if a cable modem agent wants to know its current channel designation, it "asks" the HAL, which returns the desired answer. This means that RDK, together with silicon providers, define the HALs, or "function files," designated as "H" files, to define the functionality of each hardware device.

The portfolio of broadband devices communicates via the DBUS/RBUS message bus, for testing and diagnostics and related functions, as well as cloud interface components, such as WebPA, TR-069, SNMP, and various other cloud-based agents.

The RDK stack is expandable, via agents and HALs, to accommodate different device and network types modularly and as needed.

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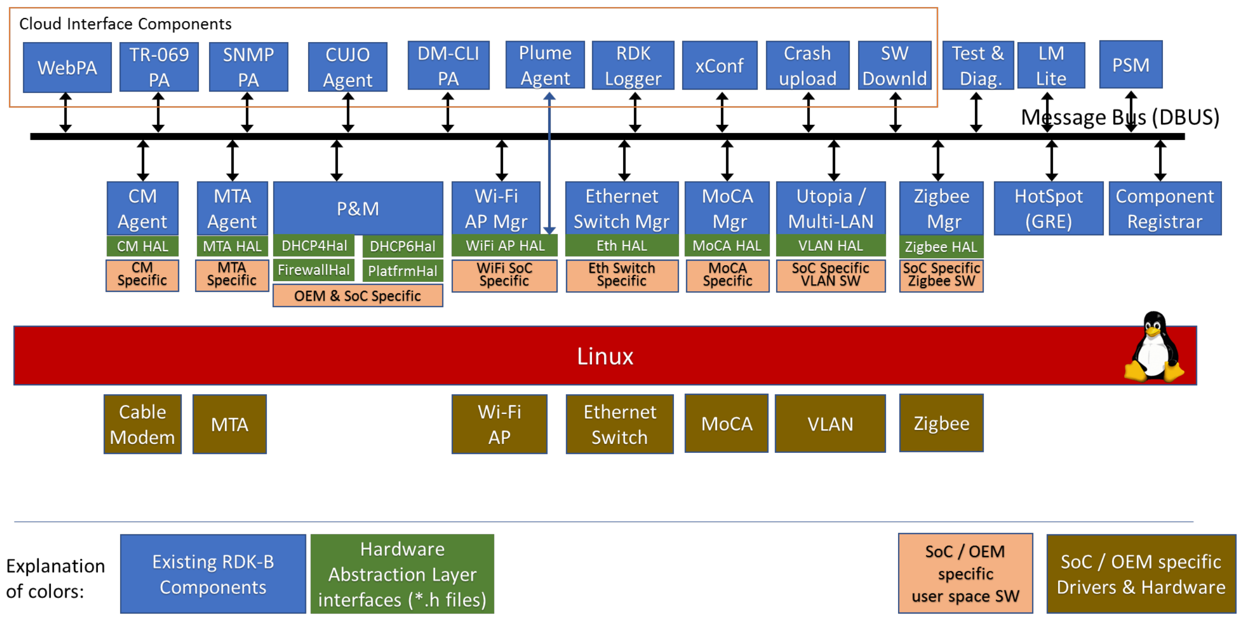

Figure 2: The RDK-B Stack

6. Access Network Evolution

The "last mile" or access network infrastructure is clearly evolving, from single access (DOCSIS or DSL or PON) to multi-access (DOCSIS and DSL and PON). As mentioned, this is in large part attributable to marketplace consolidation. An operator may have started out with traditional hybrid fiber-coax (HFC) plant, with IP-based services running on broadband DOCSIS infrastructure, then grew by acquisition to support systems with additional access network configurations: Telco DSL, as is often used as a backchannel in satellite-based distribution, or fiber and PON topologies common in enterprise networks. Presently, it is the exception, not the norm, to conjure a major network operator with "only" one access network topology; hence the need for RDK to extend its applicability into all access network types.

This is an evolution that is happening progressively and worldwide. In Switzerland, Sunrise, a mobile telecom provider with assets in fixed-line telephony, TV and broadband, is acquiring UPC. Vodafone, traditionally a mobile carrier, acquired Spanish broadband/telecom provider Ono, and is acquiring portions of UPC, as well as Kabel Deutschland. In Hungary, Magyar Telecom merged with mobile carrier T-Mobile. In Norway, Telia merged with GET-TDC; in the U.K., Comcast merged with Sky; in Argentina, Telecom Argentina acquired Cablevision.

The bottom line: All of them are becoming (or instantly became) multi-access networks, far from their single access network origins. When becoming a multi-access network provider, build options span greenfield (usually fiber), brown field, and "other," described below:

Greenfield: A build environment in a new neighborhood, development, or area previously unserved. Greenfield builds also apply to service areas damaged or obliterated by natural disasters, such as hurricanes, tornadoes, fires and earthquakes. In general, green field builds tend to favor fiber installations.

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Brownfield: Brown field builds generally favor designs that preserve existing coaxial able, because of the steep equipment and labor costs associated digging and pulling fiber. Brown field builds are generally based on existing IP connectivity standards, like DOCSIS.

Other: If there's one thing that's common in access network topologies, it is variances. In the "other" category, some designs call for direct Ethernet connections, although this is generally considered cost-prohibitive.

6.1. Multi-Access Networks Require Unified Software

When transitioning from a single access network to multiple access networks, a need arises for unified software. RDK's broadband profile is a unified software environment that exists to provide a common method to manage various broadband functions on gateways and routers, such as home networking interfaces, device management, and diagnostics.

The rationale for unified software is perhaps best observed by considering the alternative: Different core stacks for each component means that all common functions – testing, debugging, optimizing, releasing, etc. – are handled multiple times, from multiple sources. The permutations can be daunting, involving multiple SoCs, OEMs, integrators, and operators.

A unified software environment, by contrast, enables speed and ongoing optimization. Speed, in terms of more quickly resolving problems, adding features, and deploying applications. Likewise for optimizations, such as pre-emptively identifying and resolving network, stack or device issues before they impact customers, and via machine-level telemetry data and analytics.

A unified software framework is depicted in Figure 3, below. From bottom to top: Access network entities are embedded into SoCs, which become individual, pluggable modules that can be addressed from a unified RDK software layer via each entity's respective HAL. The modular approach enables operators to plug required access network types into the RDK. On the top, applications and services, from home security to WiFi and network controls (both internal and customer-facing) are unaffected, other than their expanded ability to run over additional types of access networks to end users/devices.

Figure 3: Access Network variations in SoCs

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6.2. Modular Access Network Architecture Details

Figure 4 illustrates the architecture of the RDK broadband stack, optimized for extensibility across access network variations. An operator tasked with onboarding or extending its infrastructure to support EPON, for instance, would specify an ONU (Optical Network Unit) with an RDK SoC, and its HAL would communicate through its agent over a common message bus (DBUS, in Figure 4) to cloud interface components, such as webPA, SNMP, testing and diagnostics, and devices, like WiFi extenders and security platforms.

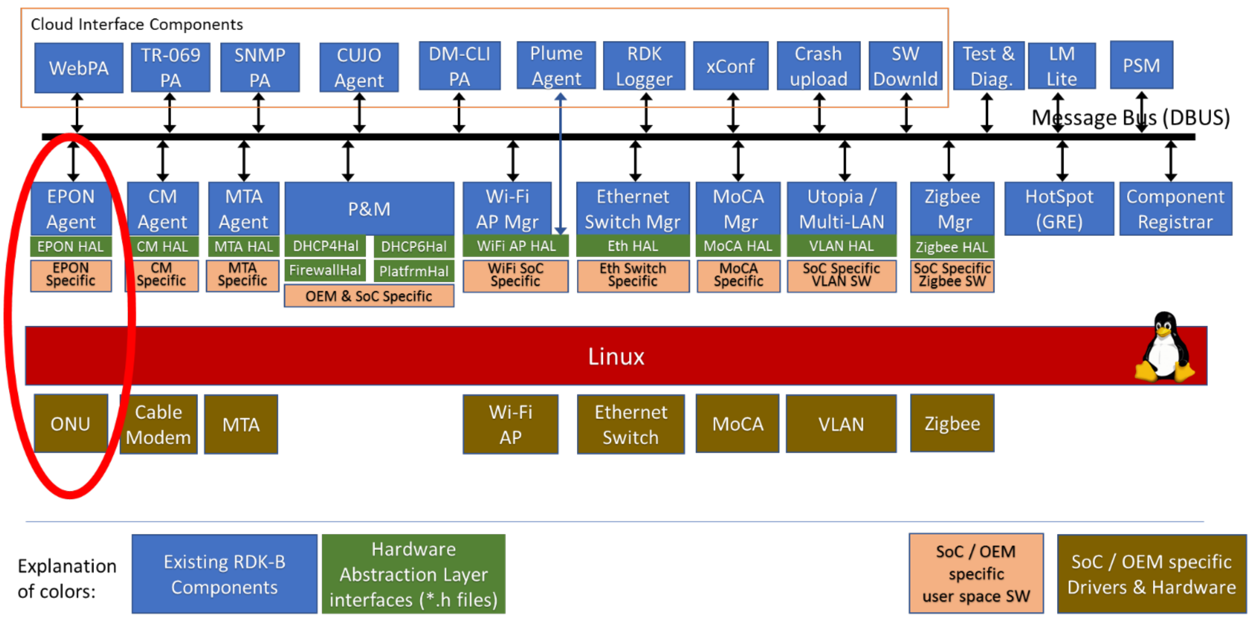

Figure 4: An EPON module plugged into the RDK broadband stack

6.3. Message Buses and Component Registrars

A key component in any modular software architecture is a Message Bus, necessary, in this case, to relay information between RDK-based devices, and the cloud-based services they enable. Figure 5 depicts a "now vs. next" treatment of message buses and component registrars within RDK's broadband profile. In the "now" approach, on the left, a standalone component registrar (Linux DBUS) manages the flow of device-level data to and from connected devices. In the "next" treatment, on the right, individual devices communicate over an RBUS broker. The component registrar recedes, with the RBUS broker forwarding component information much like a traffic forwarding function; Unix or TCP sockets are used for the transfers.

Generally speaking, while DBUS is a stable, standard and relatively common Linux tool for moving messages from one module to another, it is somewhat heavy and slow. By contrast, RBUS is a new tool/utility, which performs the same functions, but in a faster and lighter way. It is an example of ongoing code optimization within the RDK community, to more efficiently communicate between components in a manner analogous to web or TCP sockets – where "socket" is analogous with the port, and the code is vastly optimized, in terms of size and processing power.

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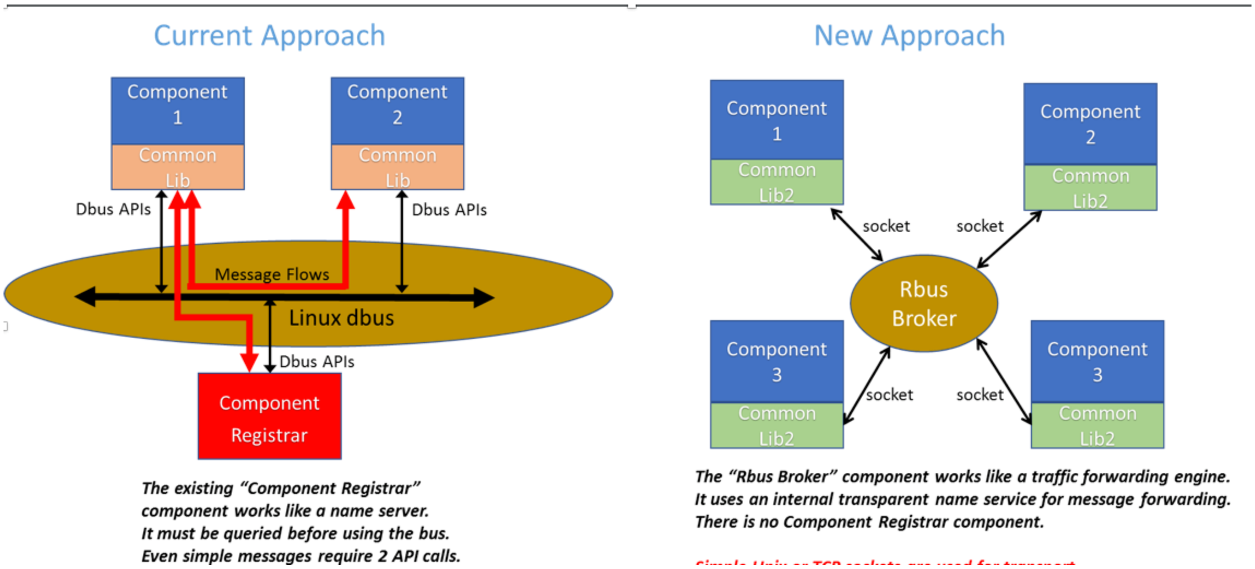

Figure 5: "Before and after" messaging configurations within the RDK broadband profile

Conclusion

Global service providers are adapting their last-mile / access network infrastructure in step with marketplace developments, and in particular, industry consolidation. Industry consolidation created an environment in which known, single-access topologies – whether DOCSIS, DSL, or the PONs – are rapidly ceding to multi-access environments, requiring support for different connectivity fabrics. Recognizing this, and at the request of its service provider members, the RDK community responded with a modular, plug-and-play method to augment access network types within RDK broadband profile. Operators who started out with a DOCSIS-based access network can now offer the same devices and services within network topologies like Digital Subscriber Line and E/G-PON.

Such modularity happens in a manner that is non-impactful to existing broadband services and devices. An RDK-based gateway, running a customer- or internal-facing UI to manage WiFi health, for instance, can be adapted in the background to run wherever it lands, be it a DOCSIS, DSL or PON environment. This represents but another chapter in the RDK mindset of continuous improvement and delivery, backed by a community of 400, and serving more than 50 million devices, worldwide. This matters as a mechanism to continue to increase the reach and scope of RDK's advantages, into multiple network types.

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Abbreviations

CCSP	Cisco Core Service Provider
DOCSIS	Data Over Cable Service Interface Specification
DSL	Digital Subscriber Line
EMTA	Embedded Multimedia Terminal Adaptor
EPON	Ethernet Passive Optical Network
GPON	Gigabit Passive Optical Network
HAL	Hardware Abstraction Layer
IoT	Internet of Things
MoCa	Multimedia Over Coax Alliance
OEM	Original Equipment Manufacturer
ONU	Optical Network Unit
RDK	Reference Design Kit
SNMP	Simple Network Management Protocol
SoC	System on a Chip
TCP	Telecommunications Control Protocol

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