broadpeak

RDK Member

CPEs to open up and become smart… or die

Broadpeak White Paper

INTRODUCTION

Broadpeak designs and manufactures video delivery components for Content Providers and Network Service Providers deploying streaming services. Its portfolio of solutions and technologies powers the delivery of movies, television programming, and other content over managed networks and the internet for viewing on any type of device. The company's systems and services help operators increase market share and improve subscriber loyalty with superior quality of experience.

Launched into the video and communications industries about a decade ago, RDK relies on open source software development to engage members to continually, and rapidly, innovate. Originally a joint venture between Comcast and what was then Time Warner Cable, Liberty Global joined soon after to create a global entity. The result was the RDK software stack, an open source distribution of a Linux based platform, which provides a template for building CPE software for operators, OEMs and SoC providers.

By using an open source platform like RDK, operators can take advantage of contributions by others to address common technical challenges across different broadband, video, and IoT devices. The RDK community is currently comprised of more than 500 companies including CPE manufacturers, SoC vendors, software developers, system integrators, and service providers.

This whitepaper discusses how fast video consumption is now evolving and needs open and innovative technical frameworks, such as the RDK software stack, to keep up with viewers' demands. It then gives practical examples on how such frameworks can help consumer devices become smart and get easy access to added value components, in particular for video streaming.

https://broadpeak.tv

OPENNESS AND INNOVATION

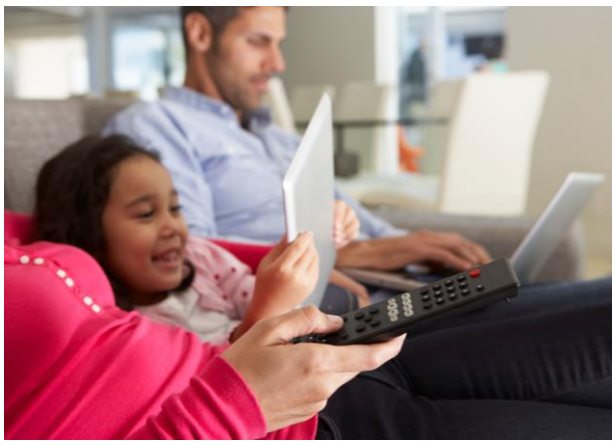
It is quite striking to see how much video consumption in the home has evolved in the past decade. Ten years ago, smart devices, such as smartphones, tablets and smart TVs, gained popularity in the consumer marketplace. All of these devices have two essential characteristics in common: they are connected to the Internet and have a screen that is wide enough to display video. With the introduction of these devices, video was no longer distributed exclusively through dedicated broadcast networks and a new distribution technology was developed to allow video streams to adapt to the different screen sizes and various internet standards, Adaptive Bit Rate (ABR) streaming. In the ABR process, the client on the device evaluates the available bandwidth and CPU capacity in real-time and adjusts the quality of the stream up or down to create the optimum viewing experience for that device in that location. ABR streaming effectively enables video to merge into internet traffic using standard Web services and HTTP distribution.

Upon its introduction, ABR was quickly utilized by a wide number of companies and is still growing at an impressive pace. So, what makes ABR so successful, and what is so smart about the devices that rely on it? The answer is twofold: openness and innovation.

Openness refers, in this context, to the fact that a system is natively designed to receive new content and functions that are not provided exclusively by one single actor, but from an infinite number of specialists who are all invited to contribute. These devices are, therefore, open to global contributions, which leads directly to innovation and more rapid deployment of features and services. For example, the iPhone's AppStore currently offers nearly 2 million applications. No cell phone manufacturer could approach this number using proprietary applications on a closed system device.

How does openness impact video applications? We all have access to smart devices, which are more innovative than any other proprietary customer-premises equipment (CPE) and can now receive video via standard Internet. These devices now compete directly with traditional set-top boxes (STB), which were once the exclusive point of reception for linear broadcast TV.

Two additional factors have eroded the prevalence of the STB. First, smart devices are no longer limited to small screen mobile devices. Streaming devices such as Apple TV, Firestick, and Chromecast are now competing with the main TV screen. Second, open systems have access to a much broader content set, offering leading global streaming apps such as Netflix, Amazon Prime, and Disney+. STB vendors responded by bringing a new set of smart and open devices to the market and adopting similar principles, and 3rd party content apps are now common on STBs in most parts of the world.



The adoption of open frameworks is not only about adding more content. Many other innovative technologies provided by third parties can be integrated to an open system, and the latest developments of RDK video framework, as further

described in the following chapter, were designed with this purpose in mind.

If you look at devices in the home, one has remained in a blind spot: the home gateway. The home gateway is the device which serves as an access point to the Internet and manages the home network, typically a DSL modem, an Optical Network Terminal (ONT), or a cable modem. Most gateways still run proprietary and monolithic firmware, which do not welcome third-party components and therefore miss out on a wider pool of innovation, such as IoT, access control, or network optimizations from the WAN or home Wi-Fi. Because of ABR, video streams can become just another form of standard Internet data that converge with, and get managed by, the home gateway, rather than remaining isolated with its own distribution and specific receivers.

For the near future, video will continue to require more bandwidth and demand higher delivery quality than any other application. Gateways need to play an important role in the migration from broadcast to streaming, helping to resolve scalability issues and ensuring that the quality of experience (QoE) meets the standards set by traditional broadcast. The movement to openness and innovation is expanding, starting with the smart STB and advancing to its next target, the smart gateway.

MAKING CPES SMART WITH RDK

The RDK community currently includes more than 500 companies who are actively working on the core RDK code. This allows operators to focus more on innovation at the app layer and the end customer experience rather than the intricacies of their customer premise devices.

The first well-known deployment of RDK was in Comcast's X1 video experience, at the time a complete break from what had been a blue grid-styled guide. RDK now powers Liberty's Horizon, Cox's Contour, Rogers' Ignite TV, and Shaw's BlueSky TV. Subsequently, RDK released a broadband stack, which currently supports a wide range of network access solutions including DOCSIS, PON, and DSL. RDK's newest profile addresses other connected-home devices, such as cameras. Today, more than 80 million RDK-based devices have been installed in homes throughout the world.

The latest software version, RDK4, provides a framework for integrating external apps, and includes the concept of Downloadable Application Containers (DAC). DACs encapsulate applications, providing increased stability, security, and resource management within the rest of the system. DACs allow external apps to be downloaded and displayed on customer premise devices, without any modification. RDK4 is also leveraged by the RDK Video Accelerator, which is a pre-built IP set-top box that has been pre-integrated with an App Store and premium OTT apps. This allows operators to quickly launch a service that includes access to hundreds of applications.

The RDK Accelerator program will soon be extended to the broadband solution, providing its community members with easy access to pre-integrated apps for their gateway. Since RDK provides a common app integration layer that is independent of the underlying access technology, operators can easily deploy new apps even with multiple access technologies in their network. RDK's open framework provides a much easier app onboarding experience for both app solution providers and the operators who are using RDK on their gateways.

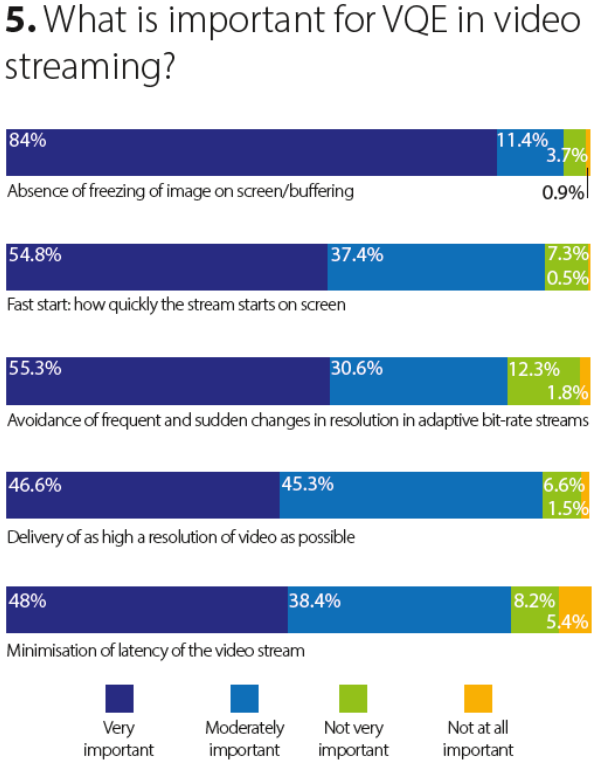
VIDEO DISTRIBUTION, A CRITICAL APPLICATION TO ADDRESS

Initially, home gateways limited their scope to the IP transport layer, and their design was driven by cost savings. Recently, a growing number of operators have begun deploying more advanced gateway models that include features at the application layer, which helps to differentiate the services offered by the operator. This is particularly common in the higher-end fiber and DOCSIS markets - the introduction of new technology is often a good opportunity to also initiate product strategy changes.

This new design, however, has generally been built on existing monolithic foundations, and the applications are provided by a single vendor, often the CPE manufacturer or an exclusive firmware developer. Migrating to an open environment removes the limitations imposed by provider exclusivity, and makes gateways more innovative, flexible, and easier to manage and operate.

Once applications can easily be added and managed through an open environment, the question becomes: What applications are most relevant to the home gateway? Video streaming accounts for over 60% of internet download traffic. Any added service that improves video quality and efficiency has a significant positive impact on many subscribers, and directly impacts on-going investments in network infrastructure. Internet traffic is continually increasing, so even a small optimization in the distribution has significant economic benefits.

Sanvine – Global Internet Phenomena Report 2019

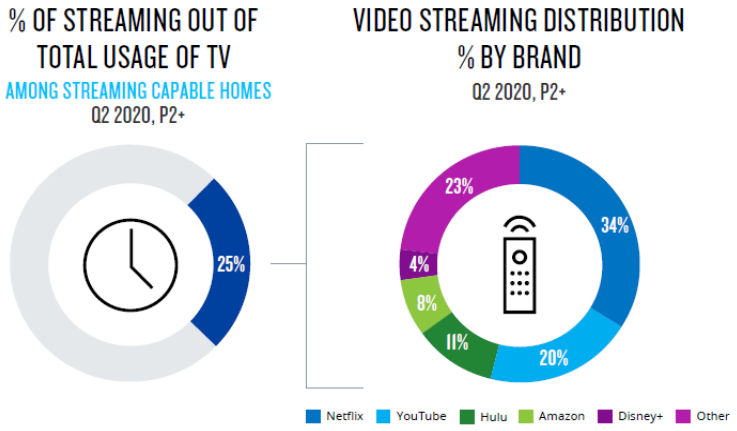


Digital TV Europe Survey 2020

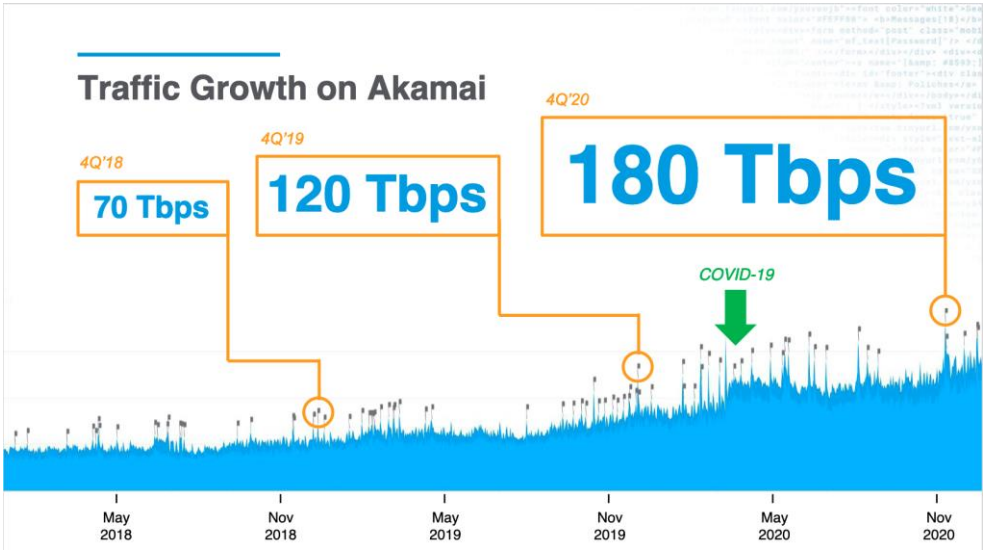
Internet data delivery is by nature variable, which conflicts with the fact that a video player must always consume data at a constant rate or it will simply freeze, producing the worst effect on perceived QoE. Players include a video buffer to mitigate delivery variability, but the buffer adds latency, which can be particularly disruptive on QoE during live events. Therefore, a dedicated video app strategically placed in the home gateway is extremely useful to optimize the network resources and assure a steady delivery on the WAN side, and also guarantee video QoE on the LAN side.

A dedicated video delivery function becomes even more important as TV distribution moves from legacy broadcast on a dedicated network to ABR streaming over the internet. Today, about 75% of TV video consumption is through broadcast, according to Nielsen 2020 Audience Report. When all that traffic moves to the internet, bandwidth consumption will increase dramatically, four times higher than today in average volume. And that number will soar as live events move to the internet, creating punctual peaks in traffic demand. Popular sport events, for example, are almost exclusively distributed on the broadcast network and haven't yet deeply penetrated internet distribution. But this is changing quickly; in 2021, we have seen pure streaming actors like DAZN owning Football Serie A rights in Italy, and Amazon Prime owning Champion's League Football game rights in Germany and Ligue 1 Football in France. For the first time, these major events will be exclusively distributed in ABR streaming over the internet, producing huge peaks of traffic which, if not properly managed, can cause congestion in parts of the network and degrade the QoE. In the U.S. while not exclusive, NFL games can now be streamed on devices such as Amazon Fire TV, Apple TV, Chromecast, and Roku.

While home gateways will become strategic in video distribution, it is worth noting that even as broadcast delivery wanes, set-top boxes can still have a major role if they support ABR streaming and are based on an open architecture that can aggregate 3rd party services. Users are now able to choose their playing device separately from their video service; the applications are no longer dependent on the hardware and OS. As long as the STB supports ABR streaming, and can aggregate outside services, it acts as any other smart device, but with an HDMI port connecting to a TV screen rather than its own display. The decision to provide a set-top box along with a video service, which makes things easier for users and preserves the STB rental model, becomes a marketing decision rather than a technical one.



Nielsen Total Audience Report, August 2020



Akamai Investor Summit 2021

In summary, video consumption continues to increase pressure on the Internet, in terms of both volume and delivery quality. This pressure will be multiplied as popular live events move to the internet, along with their accompanying traffic peaks. Network innovations and optimizations are necessary to cope with this transition, and home gateways, the intersection of the WAN and each user's home LAN, is a strategic point of implementation. Moreover, set-top boxes will not be in every home and not all video services will go through the network operator's Multi-content delivery network (CDN) streamers, so the home gateway may eventually be the only point in the distribution that will be fully owned and controlled by the operator, and the only option to steer and regulate traffic on its network.

EXAMPLES OF VIDEO SERVICES IN SMART GATEWAYS AND SET-TOP BOXES

More practically, what specific features and benefits could an application dedicated to video bring to a home gateway or to an ABR-compatible STB? To answer this question, we need to identify the most important goals of the operator, as owner of these devices:

- Secure a good QoE for high value content
- Make sure the distribution can handle the peaks of big live events
- Optimize network infrastructure costs
- Offer new personalized services at the home network level

The first three points are related and linked to the WAN distribution. These can be addressed with two guiding principles: selection of the most efficient network path and personal edge caching. For the last point, we will describe below how having a personalized process inside the home, dedicated to video, can simplify distribution and be a powerful value-added service.

SELECTION OF THE MOST EFFICIENT NETWORK PATH

In internet HTTP distribution, one single piece of content can technically be delivered through different paths. Video is unique in that a small subset of content draws the largest number of requests and network operators often use dedicated paths for video in order to adapt to a particular load and QoE requirements. Operators commonly install video caches as close as possible to the end consumers, allowing popular content to be retrieved once from the local caches, and efficiently served thousands of times with a minimal impact to the core network. One of the most advanced application of caching is multicast-ABR, which enables distribution of a unique piece of content to all caches in multicast. This offers virtually unlimited streaming capacity as local caches reside in the home, guaranteeing optimum QoE for events like live sports.

An efficient selection of the best cache for a given video session is usually not as simple as picking the closest one, however, and the load or characteristics of each cache should also be considered. CDN strategies are also growing in popularity; a network operator can have its own CDN and use a public CDN such as Akamai or CloudFront to offload traffic during peaks.

An intelligent application in the gateway that manages the network path and cache selection is extremely beneficial, especially as the variety and complexity of delivery options increase to cope with demand. Also, the fact that this process is managed locally on the CPE, rather than on a centralized farm of servers in the network, makes it simpler, cheaper and more efficient, as it can rely on local and dynamic metrics.

PERSONAL HOME CACHING

As mentioned previously, securing QoE and optimizing resources is essentially about streaming as close as possible to the end user, so placing a cache right in the home is the ultimate solution for achieving these goals. Hosting a personal home cache is a principle mainly used today by multicast-ABR technology but it can also be beneficial for standard HTTP unicast.

Example use cases include:

- Pause and skip-back: These functions are growing in popularity and home caching provides both a better delivery optimization, since it is sourced from the live session itself and not from an individualized time-shifted session, and a more reactive experience for the viewer.
- Blockbuster Video on Demand (VOD) releases: When a popular VOD asset is expected, it can be pre-cached on a number of devices, which limits the associated surge of traffic at the moment of its release, and optimizes the stream quality.
- Popular advertising campaigns: Similar to blockbuster VOD releases, locally pre-caching advertising segments assures that the ad spots will properly be displayed, which is particularly valuable when using a complex audience targeting process.
- Large generic files: Beyond video streaming, the principle of home caching can easily be extended to large generic files that are widely distributed to customers, such as electronic programming guides (EPGs) and their metadata or a receiver's firmware update.

DISTRIBUTED AND PERSONALIZED SERVICE

Processing at the CPE level has two fundamental advantages; it personalizes the service, and it distributes the processing load across millions of devices. Practical examples where processing on the CPE can make sense include:

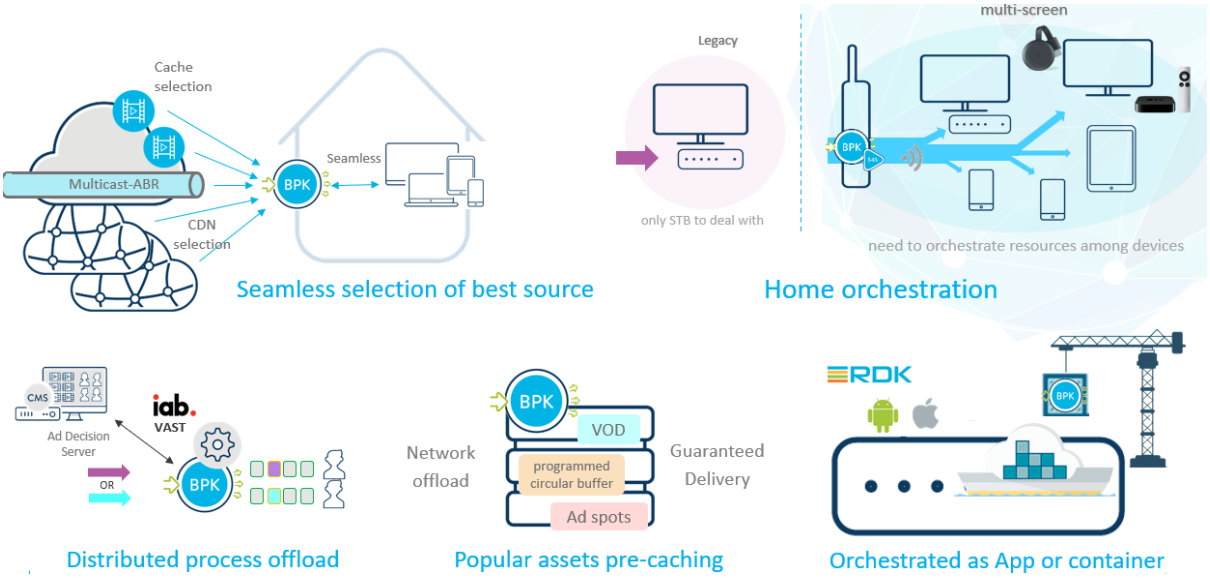
- Smart distribution of bandwidth between different devices in the home: Video streaming is often referred to as multi-screen, highlighting the fact that, unlike broadcast, which exclusively targets STBs, streaming addresses multiple devices and users in the home, all sharing the same technical resources and limitations. The distribution process must ensure that bandwidth is logically and fairly distributed, depending on the type of device or the nature of a program. When the process is left solely to client devices, some may request quality layers that are unreasonable in light of their display size or will try to flaw TCP prioritization by artificially opening several connections in parallel. This comes at the expense of the other client device QoE, and creates unnecessary demand on the network infrastructure.

- Adapt streaming to technical constraints of each device: Streaming allows viewing on an infinite number of end devices, all with variations in performance, technical capacity, screen size, and software version. Each device's video player chooses the most appropriate stream available for that device, but, given the number and lack of control, it is difficult to ensure that each device will do it consistently.

- Content personalization and targeted ads: Targeted ad insertion means that all viewers that reach an ad break simultaneously request their own personalized ad. This is a huge challenge in terms of processing load, especially during a popular event, which can be resolved by distribution at the CPE level. When combined with home caching, the ad spots can be decided and smoothly pre-cached in advance rather than all at once.

- User-defined preferences: A smart CPE usually gives the end user access to an interface that allows some level of custom configuration. Video content can also be locally managed, such as content blocking and prioritized streaming for a certain program or device.

- Beyond video, there are many other domains where specialized applications on a CPE can add significant value, especially in how the applications interact. Co-locating applications into one host helps to enrich others, such as the relationship between video and network functions, for bandwidth management, access control, or security. It is also an opportunity to correlate analytics from different domains and get powerful per-home insights that would otherwise be extremely complex to get.



CONSIDERATIONS ON CONVERGENCE WITH CLOUD EDGE

So far, we discussed opening CPEs from the home perspective, but we also need to look at it from the network side, with the perspective of edge computing. Smart CPEs are a natural extension of the Cloud Edge. As the cloud gets pushed deeper into the network, processing and caching data must occur closer to the end user in order to guarantee a better experience.

Multi-access edge computing (MEC) is also a promising concept, particularly for 5G technology. MEC seeks to open the edge to 3rd party applications and encourage innovation, similar to the approach for smart devices. This provides an opportunity for the cloud to go even beyond the access network and enter into the home. This concept is starting to be articulated and advertised by some cloud specialists such as Intel, AWS, or Red Hat, and generally referred to as user, device or on-premise edge.

Conversely, the success of the cloud can guide decisions about opening smart CPEs. For instance, using virtualization, containerization, and orchestration standards, cloud specialists are now able to decorrelate the application layer, the deployment environment, and the hardware. This has provided datacenters with more flexibility in the choice of components, better interoperability, easier deployments, faster innovations, elasticity for dynamically sharing, and optimizing resources.

Similarly, successful smart CPE implementation relies on a layer over the operating system that abstracts the physical components, including many basic functions, and offers the ability to easily download and manage 3rd party application containers. The segmentation that containerization offers also works very well to manage a wide variety of processes and functions, to ensure that the failure of one doesn't affect all others running on the host, and to efficiently distribute the host shared resources. Cloud also includes simple and standard API logics for the different 3rd party applications to be able to interact with each other and could be used as a reference when developing further smart CPEs, especially to prepare for a likely convergence in the future.

CONCLUSION

Concepts such as containerization, open applications and APIs are now largely adopted by the telecommunications industry, whether they be Cloud, Edge or 5G. It is only logical that they should also apply to the CPE, the natural future edge of the IP network. Both set-top boxes and home gateways can no longer afford to rely on closed and proprietary designs, but instead must follow these "smart" principles that are already widely developed in the industry if they don't want to become obsolete.

The RDK framework embraces this philosophy and is the first initiative to address both set-top boxes and home gateways in a consistent manner. For gateways in particular this development is key considering that video distribution already represents most internet traffic and will continue to grow as live events move from traditional broadcast to streaming. With its open framework, its strong operator footprint, and its ability to adapt to individual use cases and environments, it is certainly a very good solution as the OS for smart CPEs.

Broadpeak's nanoCDN™ is a video distribution application directly embedded in CPEs that is already widely deployed and known as a particularly robust and evolved multicast ABR component. It is constantly evolving to improve the quality of video services, for optimized ABR distribution and beyond. The nanoCDN™ has been adapted to fit into the RDK framework and demonstrates the kind of application that can easily be installed and managed as an external RDK add-on to significantly enhance a video service and bring great added value to a CPE.

Video is well on its way to being totally absorbed by the internet, and both technology providers and operators must start preparing now. Leveraging open platforms and adopting the principles of separation of hardware and applications will allow them to keep up with the pace of innovation and meet the needs of tomorrow's environment.