TECHNOLOGY BRIEF

Intel® Connected Home Technologies

Transform Digital Living with Intel's End-to-End Network Infrastructure Solutions

Reduce operating expenses and boost subscriber satisfaction and retention using Intel® technologies.

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Increasing Subscriber Expectations

Home broadband users are consuming more network bandwidth than ever: simultaneously streaming programs to the TV, playing games in the cloud, watching videos on their phones, working in home offices, and more. Such activities are putting enormous demands on access and home networks, while subscriber expectations for seamless, secure connectivity across the entire home are higher than ever. When new services, like 8K Ultra HD and virtual reality (VR) streaming become available, users will presume they can get broadband speeds that are up to the task.

Often exceeding the capability of a single gateway, subscribers expect consistent wireless performance throughout their home, regardless of its size. It is not uncommon to have coverage issues in a significant portion of the home, especially when a subscriber puts the gateway in a corner or tucks it away in an office. Poor coverage is not just a subscriber problem; it is also a problem for service providers because they get complaint calls, whether it is their fault or not, resulting in higher operating costs due to unnecessary service calls and truck rolls.

Subscribers also want their network to be protected from cyberattacks, although they are connecting more and more devices to the network, which increases their vulnerability to hackers. Another issue is many Internet routers fail to defend users against known malware due to outdated firmware. Many newly purchased routers are similarly exposed, according to a Wall Street Journal test of 20 new home Internet routers that found half had outdated firmware,[1] leaving millions at risk.

Control and ease of use are also important to subscribers. They want a simple way to set parental controls or assign guest access. It should be easy to add new smart devices to the network and manage them. Subscribers are also interested in new services, such as voice control, video surveillance, shopping, and healthcare.

Residential Broadband Consumption Stats, 2016-2021

Figure 1. Bandwidth demands are increasing.[2]

Service Provider Challenges

Service providers must address higher customer expectations in a cost-effective manner in order to successfully compete against established and new players in the market. This means finding ways to get more from their capital investments while minimizing operating expenses (OpEx).

However, many service providers have to cope with fragmented networks that use various types of copper and fiber, which drives up operating costs. There are also higher costs associated with deploying multiple types of customer premises equipment (CPE), each supporting a different access technology, like DSL and passive optical network (PON). As new access technologies (e.g., VDSL, VDSL35b, G.fast, LTE, and 5G) come into the home, service providers will need flexible intelligent 10G PON gateways with support for a combination of access technologies, and strong security and privacy protection.

Transforming Digital Living

Many service providers are re-architecting their network infrastructure in order to increase flexibility and reduce OpEx. This is a transition to software-defined infrastructure (SDI), whereby software-based network functions running on general-purpose servers are replacing relatively expensive proprietary, fixed-function equipment. The underlying technologies for this architectural change are founded in concepts from network functions virtualization (NFV) and software-defined networking (SDN).

A similar SDI revolution is expected to take place at the edge of the network and in home networks. Service providers will be able to add new services to CPE with a simple software download, thus improving time to market and protecting CPE capital investments. The possibilities are only limited by the imagination and include security services adapted to when users are at home or away, VPN services customized to individual customers, and content subscriptions ordered on-the-fly by customers. SDI will transform digital living, boosting subscriber satisfaction and retention while delivering substantial cost savings.

Since the inception of NFV, Intel® reference designs have been widely used by network equipment vendors to develop flexible, high-performance solutions, designed to deliver new user experiences and services. Intel® technologies help them deliver end-to-end network infrastructure, spanning the home, a variety of access networks, and data centers. This brief describes these Intel technologies and how they help simplify the delivery of new services to the home.

Overview of Intel® End-to-End Network Infrastructure Solutions

When subscribers download data from their home broadband connection, there's a good chance this data will pass through a number of Intel® processors on its journey. That's because the Intel® architecture is well-suited to handle such networking functions. Intel offers a broad portfolio of products and technologies used to design network infrastructure, spanning data centers, core and access networks, and home CPE, as shown in Figure 2.

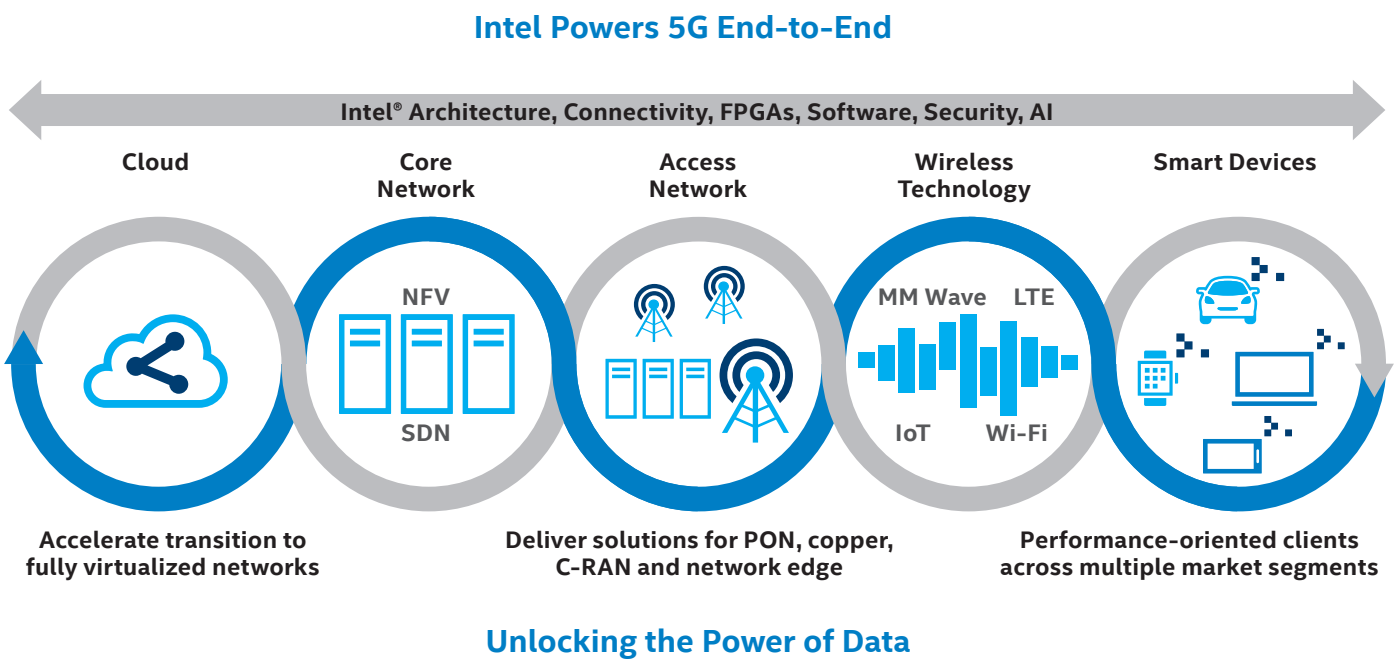


Figure 2. Intel® solutions are employed across the entire network.

One reason Intel® solutions are popular is their extensive support for virtualization, which is a fundamental technology for building SDI. Virtualization greatly simplifies the deployment and management of software-based network functions and services by eliminating hardware dependencies. Some of the benefits of virtualization include improved flexibility, security, productivity, and total cost of ownership (TCO).

The following sections describe Intel's role in the development of end-to-end network infrastructure.

Solutions for the Data Center and Cloud

Service providers face a dynamic and unpredictable business environment that demands rapid innovation and ever-improving customer experiences. The enterprise data center plays a major role in achieving these objectives, making it a competitive advantage to implement scalable, flexible, and agile computing technology. Helping to meld legacy and new services, SDI paves the way for enterprise clouds to accommodate traditional and cloud-native applications with ease.

Delivering this and more, Intel® server processors power over 90 percent of the world's cloud data centers.[3] With unique built-in capabilities, Intel technologies, such as the Intel® Xeon® processor E5 family, are built to overcome key challenges, like network latency, infrastructure security, and power inefficiencies. Moreover, Intel Xeon processor-based servers are optimized to deliver industry-leading virtualization performance and energy efficiency across a wide range of server configurations. Well beyond server processors, Intel provides network interface cards (NICs), solid-state drives (SSD), field programmable gate arrays (FPGAs), system-on-chip (SoC) products, silicon photonics as a connection mechanism in the data center, and resource monitoring and control technologies, among other solutions.

Solutions for the Core Network

Intel is enabling and accelerating the shift to agile, cloud-ready network architectures by leading ecosystem alignment for the rapid delivery of standards-based solutions for software-defined, virtualized networks. One enablement example is the Intel® Open Network Platform (Intel® ONP) server reference architecture, which is optimized for NFV and SDN, and brings together key hardware and open software. Other Intel offerings for core network infrastructure are Intel® QuickAssist Technology, Intel® Ethernet products, Intel® Resource Director Technology, Hyperscan content inspection technology, and Data Plane Development Kit (DPDK).

Solutions based on Intel ONP are replacing fixed-function network appliances with commercial off-the-shelf (COTS) servers running software-based network functions (e.g., for evolved packet core [EPC], switches, firewalls, etc.).

These functions are implemented in virtual machines, allowing them to be automatically scaled, moved, and service-chained to meet ever-changing demands. This approach enables a network that is smarter and more programmable, automated, adaptable, and open than traditional networks.

Service providers can also take advantage of Intel's thriving Network Builder's community, created to foster the necessary support, matchmaking, and collaboration across the ecosystem. This community is navigating the change—from initial discovery of NFV and SDN solutions, to proof-of-concept pilots and final deployments.

Solutions for the Access Network

As video and bandwidth-intensive application use increases, home subscribers will require higher data speeds on the order of multiple gigabits per second (Gbps). To meet this demand, service providers will need faster connections between homes to core networks, like G.fast 212 MHz, 5G and PON links, or a combination of 4G and DSL.

For service providers deploying 5G networks, Intel offers solutions for smart cells, cloud radio access networks (C-RAN), optical connectivity, and 5G modems.

Intel® silicon photonics optical transceivers with extended temperature range for outdoor environments enable fiber connectivity from the wireless tower to the base station, providing high-speed 100Gbps bandwidth for distances of up to 10 km.

With the growth of optical access networks, flexible Intel technologies support both the head end or central office optical line terminals (OLT) and customer premises and infrastructure optical network unit (ONU). These technologies are designed to integrate with the existing mobile fronthaul/backhaul and passive optical networks.

There is a range of implementation options, including dedicated chipsets and FPGAs, so service providers can select the approach that best fits their requirements. Intel's ONU solutions are integrated with the latest home networking technology, streamlining the creation and deployment of CPE.

Intel offers a range of solutions for traffic management, backplane switch fabric, protocol bridges, and channel bonding. Intel® FPGAs used for 5G have advanced DSP capability, hardened floating-point processing, and high-speed 25 Gb transceivers. For more information about Intel FPGA-based solutions, visit www.intel.com/connectedhome. IMO implementations can take advantage of Intel® Arria® and Stratix® FPGAs, featuring high-performance DSP blocks and logic elements (LEs). For microwave backhaul, Intel and a partner offer a complete solution, including modem and switch, and Intel offers a scalable modem for microwave fronthaul.

Table 1. Intel® AnyWAN™ GRX550 family architecture supports many WAN and LAN technologies

WAN	LAN
LTE	Wi-Fi
PON	Ethernet
DSL	USB
G.fast	Bluetooth*
Ethernet	DECT
USB	Voice

Solutions for the Home

As bandwidth increases and use cases continue to evolve, the requirements being put on the home gateway are significant. New services, improved coverage, security, and ease of use are just a few of these requirements. These capabilities can be achieved using the Intel® AnyWAN™ GRX550 home gateway, designed to help service providers quickly deliver new services to home subscribers while saving costs, simplifying operations, and meeting evolving customer expectations. Unlike other solutions in the market today, the Intel AnyWAN GRX550 family architecture provides the flexibility to connect any wired or wireless technology, including optical fiber, DSL, G.fast, and hybrid LTE/DSL (Table 1).

Inside the home, Intel technologies enable an intelligent, context-aware home network infrastructure that can deliver consistent Wi-Fi connectivity to every corner of every room, even as more devices get connected. By making it easier to add more smart home products and services to their offerings, Intel solutions can help service providers increase average revenue per user.

Benefits of Intel's End-to-End, SDI Offerings

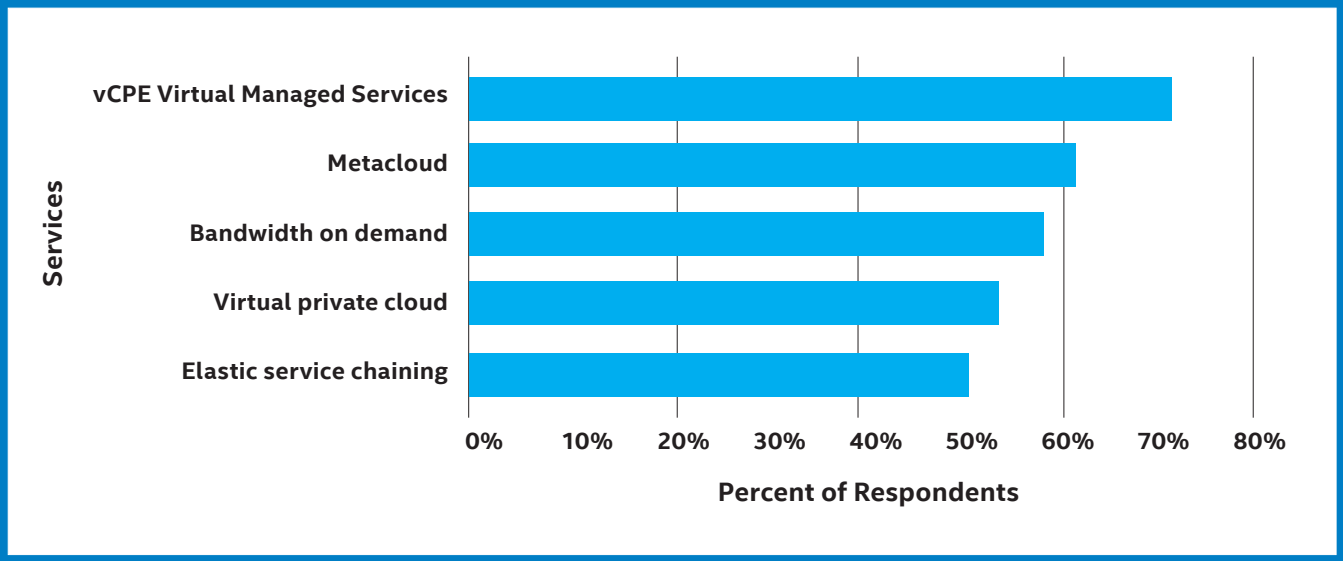
SDI is more than a single technology; it is a combination of compute, storage, and network architectures defined by hardware and software solutions and processes. SDI helps minimize supplier lock-in in favor of commodity hardware and industry-defined open standards and protocols.[4]

By providing SDI solutions, Intel aims to deliver the following benefits to service providers and subscribers:

- **Improved security and privacy –** End-to-end encryption and secure platform technology.
- **Improved user experience –** Relatively easy deployment of new software-based services.
- **Ease-of-use –** High level of interoperability and compatibility with legacy standards.
- **Lower CapEx –** Equipment consolidation on general-purpose computing platforms.
- **Reliable service –** Quick provisioning and failover capabilities.
- **Lower OpEx –** Remote management of network elements.

The Promise of SDN and NFV

Software-defined infrastructure (SDI) developed from network functions virtualization (NFV) and software-defined networking (SDN) concepts is reshaping network infrastructure from end to end. Service providers expect to create new revenue sources by implementing a number of SDN/NFV applications, according to a survey by IHS Markit.[5]



Transform Digital Living with Intel® Connected Home Technologies

SDI will transform digital living by making it easier and more economical to bring new services to subscribers in ways that increase service provider profitability. Today, Intel architecture is widely used by SDI developers because it is a scalable and flexible architecture that brings performance and cross-platform compatibility to data centers down to clients. In the future, Intel architecture will be extended to the home gateway space, allowing service providers to save time and resources when developing SDI-based gateways for the home.

Home Gateway Overview

The Intel AnyWAN GRX550 family architecture is well suited for mid- and high-end home gateways and routers. These network processors use the same peripheral interfaces, enabling the reuse of existing software across a wide range of applications, including any kind of gateway, router, or other home infrastructure device. This allows equipment and service providers to extend the value of their infrastructure investments and more smoothly upgrade existing designs.

A multicore network processing unit (NPU) subsystem, combined with hardware acceleration and the integration of all standard features into a single device, makes the Intel AnyWAN GRX550 Home Gateway NPU series a powerful and compact gateway-on-a-chip solution. The NPU includes various features to help improve quality of service and virtualization performance.

Intel® Architecture

Intel® architecture combines a number of computing technologies:

- CPUs with a powerful instruction set to deliver high-performance computing.
- Hardware extensions to accelerate particular workloads, such as AES security.
- Hardware technology to reduce virtualization overhead and improve performance.
- Cache monitoring features to enable developers to tune system performance.

With a single board, gateway OEMs can support multiple access network interfaces by swapping out transceivers manufactured by Intel for LTE, PON, DSL, VDSL 35b, G.fast, Ethernet, and USB networks, as shown in Figure 3. Intel AnyWAN GRX550 Family Home Gateway NPU series and Intel® AnyWAN™ transceivers are flexible and highly compatible, supporting a broad range of technologies with a common software foundation.

Configuration Example: 11AX 4+4 Telco Gateway

MultiWAN Telco Gateway G.fast, DSL/Fiber + VoIP

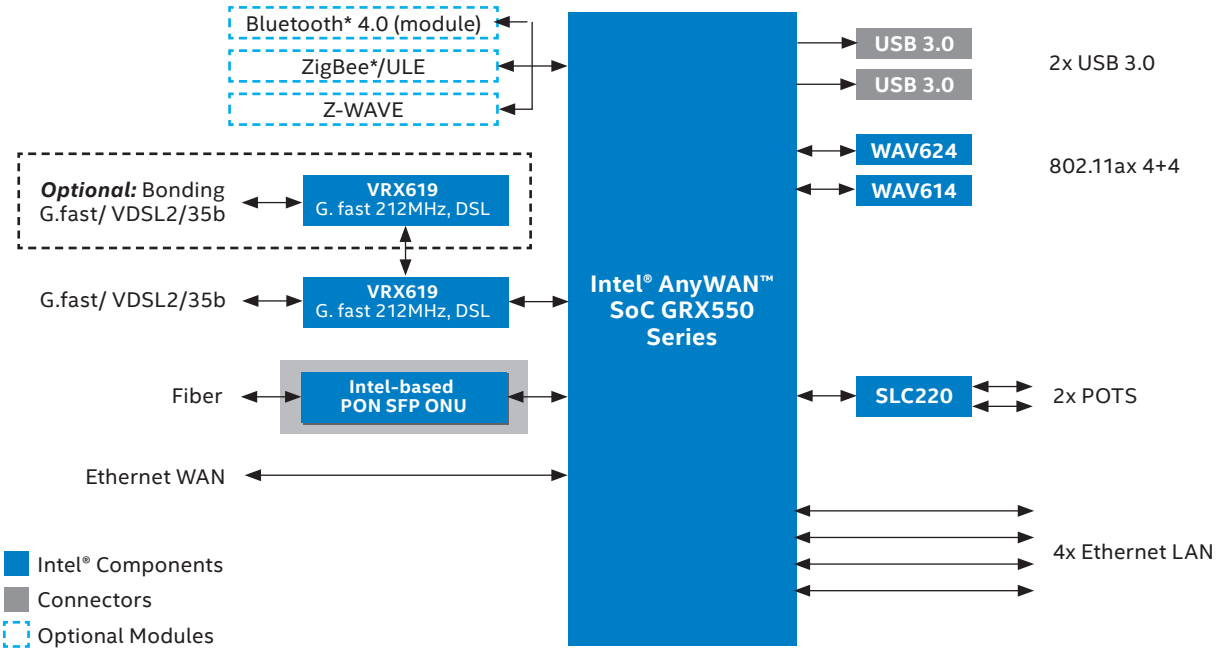


Figure 3. Example of an Intel® AnyWAN™ GRX550 home gateway design.

Table 2. Intel® Solutions for the Connected Home

Connected Home Need	Intel® Solutions
Home gateways	Intel® AnyWAN™ GRX550 Home Gateway NPU series
Copper (ADSL, VDSL, G.fast, VDSL 35b)	Intel® AnyWAN™ transceiver VRX series
Fiber	Intel® PON chipset
Hybrid LTE and DSL	Intel® AnyWAN™ transceiver, Intel® LTE VRX series modem
Fixed wireless access (4G/5G)	Intel® LTE modem, Intel® 5G modem
Home Wi-Fi connectivity	Intel® Home Wi-Fi Chipsets and Development Kits
Security and privacy	McAfee Secure Home Platform*
Smart home products	Intel® IoT platform
Ethernet	Intel® Ethernet Network Connection
Cordless phones	Intel® DECT chipset
Voice	Intel® SLIC for CPE
ISDN	Intel® ISDN chipset for terminals

Home gateway designs based on Intel® connected home technologies can also support multiple links at the same time. This capability allows service providers to take advantage of existing links, like copper, while adding a mobile link for additional bandwidth. Subscribers will get improved response through the aggregated bandwidth of both links; and service providers can offer higher resiliency if one broadband link goes down, because the second link continues to operate.

Hybrid use case examples:

- **Enhance DSL throughput –** Dynamically add wireless broadband capacity as soon as the DSL link is fully loaded, enabling service providers to offer value-added services.
  - **Improve poor DSL performance –** Service providers can significantly improve the user experience by increasing service rates to 20 Mbps with, for example, hybrid DSL+ LTE access connections. When home subscribers live far from the central office (e.g., DSLAM), performance could be limited to 1 Mbps download and 128 Kbps upload, which is hardly adequate for current day usage patterns.
  - **Offer leading-edge performance –** Hybrid DSL plus LTE/5G provides a means to boost wireline throughput up to 1 Gbps and beyond, which is even faster than state-of-the-art DSL or G.fast lines and competitive with cable and fiber-to-the-home providers.
- **Deliver instant-on –** Service providers can instantly get home subscribers up and running by providing temporary wireless access to bridge the time before the wireline broadband connection is operational. Otherwise, it could take a significant amount of time to get a new subscriber connected, given the possible need for a truck, administrative work, or coordination between network carriers.
- **Increase resiliency –** Service providers can guarantee a very high level of network availability by using wireless access (i.e., second WAN link) as a backup in case the wireline network, like DSL, goes down.

Intel Connected Home Building Blocks

The Intel connected home portfolio contains various essential building blocks, including home gateway, transceiver, modem, security, voice, and Ethernet products (see Table 2). This product breadth enables service providers to support a wide range of copper, fiber, wireless, and hybrid access network configurations.

Benefits of Using Intel® AnyWAN™ Architecture

- **Reduce design effort –** Design one board for multiple access networks without having to change low-level Universal Gateway (UGW) software. Provide more reliable and expansive connectivity throughout using home Intel technology and reference designs, including the Intel® Home Wi-Fi Development Kit, for smart home connectivity. Take advantage of these solutions to provide reliable connectivity with a dynamically organizing network, consistent throughput via dynamic network optimization, and a proactive network with real-time monitoring and self-healing diagnostics.
- **Maximize interoperability –** Benefit from open standards supported by Intel® platforms to enable smooth migrations with easy equipment reconfiguration, a consistent software stack, and support for common WAN technologies. Avoid disruption to existing infrastructure by using Intel AnyWAN solutions, which are backward compatible with legacy standards. Stay up-to-date with open standards per Intel's active participation in several standards bodies, including Broadband Forum, IEEE, International Telecommunication Union, ETSI, and OpenStack.

- **Lower OpEx –** Reduce CPE serviceability cost and truck rolls with powerful diagnostics and remote management solutions that support Intel connected home platforms. Minimize inventory using Intel AnyWAN architecture to support multiple access networks with one board. Lower development cost by using Intel's family of highly interoperable transceivers.
- **Innovate faster –** Quickly deploy the latest access networks (e.g., 5G, G.fast, and 802.11AX) that are supported, or soon to be supported, by Intel AnyWAN architecture.
- **Optimize Wi-Fi performance –** Improve the performance of home Wi-Fi networks with Intel technologies, which provide exceptional interference rejection using advanced radio frequency technology to reject other Wi-Fi interference and signals, such as LTE, Bluetooth,* and ZigBee.* Easily implement value-added capabilities, such as analytics capabilities, photo/video hosting, and cloud storage, since all the wireless functionality is performed in the Wi-Fi chipset and other hardware, thereby freeing up the CPU for other tasks.

Benefits from Intel's End-to-End, SDI Offerings

Home subscribers have high expectations for their digital world, challenging service providers to find cost-effective ways to deliver higher bandwidth and enhanced services. To help improve the home experience, developers can use Intel solutions to bring SDI to the home and design a single CPE platform that supports existing and emerging access network technologies. These efforts to transform digital living will enable service providers to increase average revenue per user (ARPU) and subscriber retention.

For more information about Intel solutions for the connected home, visit **www.intel.com/connectedhome**.

[1] Jennifer Valentino-DeVries, "Rarely Patched Software Bugs in Home Routers Cripple Security," January 18, 2016, https://www.wsj.com/articles/rarely-patched-software-bugs-in-home-routers-cripple-security-1453136285.

[2] Cisco whitepaper, "The Zettabyte Era: Trends and Analysis," June 7, 2017, https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.html.

[3] Aaron Pressman for Fortune Magazine, "Intel Counterpunches With New Data Center Chips," July 11, 2017, http://fortune.com/2017/07/11/intel-xeon-amd-nvdia-servers.

[4] Intel Whitepaper, "How Software-Defined Infrastructure is Evolving at Intel," March 2015, https://www.intel.com/content/dam/www/public/us/en/documents/white-papers/how-software-defined-infrastructure-is-evolving-at-intel-paper.pdf.

[5] IHS Markit* Research Note, "75 Percent of Carriers Surveyed Have Deployed or Will Deploy SDN This Year," September 8, 2016, https://technology.ihs.com/583348.

Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software or service activation. Performance varies depending on system configuration. No computer system can be absolutely secure. Check with your system manufacturer or retailer or learn more at intel.com.

Cost reduction scenarios described are intended as examples of how a given Intel-based product, in the specified circumstances and configurations, may affect future costs and provide cost savings. Circumstances will vary. Intel does not guarantee any costs or cost reduction.

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