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Fast, Flexible "Ethernet Network Processor"

Innovative ICT Enables Industries to 'Go Cloud'

HUAWEI

Expanding the Value of Cloud Computing

| By *William Xu, Huawei Chief Strategy Marketing Officer*

The ancient Chinese philosopher Lao Tzu wrote, "The highest good is like water, which is beneficial for all things, without striving for fame and gain." To him, water was something that follows natural laws. Huawei thinks of water as a metaphor for the company's strategic expansion; by expanding our business from communications networks (oceans) to enterprises (rivers) and devices (faucets), we aim to effectively manage the flow of massive data from oceans to rivers, and finally to faucets worldwide. Huawei's strategy is to build pipes for a Better Connected World, to fully connect people and people, people and things, and things and things.

Today, we are expanding our cloud computing operations to include enterprise cloud services. This is a natural expansion from computing, storage, and networks to services. Huawei uses a single architecture to carry private clouds, public clouds, and hybrid clouds, and provide enterprise cloud services for multiple verticals (e.g., finance, media and entertainment, and urban and public services). We are leveraging our 20-plus years of experience in ICT innovation to focus on areas where cloud computing can create value.

The IT industry is where cloud computing technologies originated, and was the first industry to explore its value. Huawei's adoption of cloud computing began with the desktop cloud. The greater value delivered by cloud computing comes from its capacity to act as a platform. Its applications are now expanding to traditional domains such as telecommunications, finance, government, and manufacturing, and fueling unprecedented levels of innovation.

In the future, cloud computing will no longer merely exist as a technical support system designed to meet enterprises' ICT needs; it will become a production system that drives the creation of new business models. For example, for new genome sequencing services in the healthcare domain, cloud computing and Big Data technologies are already being used to collect data and achieve precision medicine.

The adoption of cloud computing in the consumer domain has greatly changed people's lifestyles. However, cloud computing is also being adopted in industrial sectors, which is changing existing modes of production.

In addition to reshaping the business world, cloud computing technologies are also being adopted in public services — including government, transportation, and education — and have now grown to reach their current-level, streamlined services by eliminating information silos between large-scale applications and massive databases.

The era of large-scale cloud-based industry transformation has arrived. However, much work remains to be done. Products, solutions, and services involved in the cloud computing industry are inter-dependent. A sound ecosystem must be established for the industry to survive and thrive. In the spirit of openness, co-operation, and mutual benefits, we will adhere to our "being integrated" strategy, and work jointly with our customers and industry partners to build the cloud ecosystem. ▲

Technology News

DDN Object Storage Usage Grows to 200+ Billion

SANTA CLARA, California, USA, June 30, 2015 — DataDirect Networks (DDN) today announced the availability of the latest release of its advanced WOS®object storage platform. WOS 360 2.0 offers a full suite of new options to expand use cases in enterprises, cloud, BYOD shared storage, deep archive, video streaming, and file sync and share offerings:

• New lower cost capacity tier for long-term archive, offering deep archive for up to 30 percent lower cost than the platform's performance tier.

• 20 percent increased storage efficiency using the updated Global Object Assure (GOA) erasure coding.

• New industry-leading, ultra-high density enclosure that stores nearly 800 terabytes in a 4U array for deep archive.

• Expanded connectivity option that adds OpenStack Swift support to an already robust interface offering of S3, CIFS, NFS, GPFS, Lustre, and native REST.

CipherCloud and Cloud Security Alliance Forge Cloud Security Working Group

SAN JOSE, California, USA, June 29, 2015 — Recognized as the fastest-growing segment of cloud security, the Cloud Access Security Broker (CASB) space is still an emerging one where standards have yet to coalesce. To fill this gap, CipherCloud, the leader in cloud visibility and data protection, and the Cloud Security Alliance (CSA) are forming a Cloud Security Open API Working Group to jointly define protocols and best practices for implementing cloud data security as a part of the CASB framework. Deloitte, InfoSys, Intel Security, SAP, and other technology leaders will also contribute.

The Cloud Security Open API Working Group will provide guidance on vendor-neutral data-security implementation to help accelerate cloud services adoption. The working group plans to produce API specifications and a reference architecture to guide cloud data protection.

Xilinx Tapes-out Industry's First All-programmable Multi-Processor SoC

SAN JOSE, California, USA, July 1, 2015 — Xilinx, Inc. (NASDAQ:XLNX) today announced it has taped out the industry's first all-programmable Multi-Processor SoC (MPSoC) using TSMC's 16FF+ process, targeting embedded vision, including ADAS and the path to autonomous vehicles, Industrial Internet of Things (I-IoT), and 5G wireless systems. The All-Programmable Zynq® UltraScale+™ MPSoC enables the development of flexible, standards-based platforms by providing 5x system level performance/watt and any-to-any connectivity with the security and safety required for next-generation systems.

Picosun and Carleton Strike Gold with ALD

PORTLAND, Oregon, USA, July 2, 2015 — Picosun Oy, the leading provider of high quality Atomic Layer Deposition (ALD) solutions for industrial manufacturing, and Carleton University, Canada, report uniform ALD gold deposition on complete silicon wafers. The gold films were prepared using PICOSUN™ plasma ALD tool and a new gold precursor developed by Professor Seán Barry. The novel process was described in the talk given at the American Vacuum Society (AVS) 15th ALD meeting held in Portland, USA.

ZF TRW to Supply Next-generation Cameras to Major European Vehicle Manufacturer in 2018

LIVONIA, Michigan, USA, July 1, 2015 — ZF TRW today announced the initial contracts for its next-generation camera system (the S-Cam4 family) with a major European manufacturer.

"This fully scalable family of cameras is designed to meet the increasingly stringent regulatory requirements for advanced Driver Assist System (DAS) technologies while supporting the evolution toward automated driving," said Peter Lake, ZF TRW executive vice president of sales and business development. "We are very pleased to begin supplying these advanced cameras to a premiere European vehicle manufacturer beginning in 2018."

The S-Cam4 family includes a single lens, mono-camera version based on a standard housing and mechanical package designed to help meet test protocols such as EuroNCAP pedestrian triggered Automatic Emergency Braking (AEB) and new potential requirements including a crossing bicycle AEB test. The innovative camera family also includes a premium three-lens TriCam4 version to support advanced semi-automated driving functions.

Kerio Control 8.6 Simplifies Network Security with Remote Management of Appliances

SAN JOSE, California, USA, June 23, 2015 — Today Kerio Technologies released Kerio Control 8.6, enhancing its easy-to-manage and powerful all-in-one security solution for small to mid-sized businesses with the introduction of MyKerio — a new centralized management web interface, enabling users to monitor and configure multiple Kerio appliances remotely. The latest release also includes faster traffic, bandwidth, and content rule configuration, improved IPv6 support, and more control over detecting and protecting against Denial of Service (DoS) attacks.

"Cloud-based MyKerio has been designed to make life easier for our customers and partners who have multiple Kerio Control appliances," said Heather Paunet, Director of Products. "Users can now go to one place to manage them all anywhere, anytime from our web-based MyKerio dashboard. We've also made it much simpler to configure traffic, bandwidth, and content rules by allowing multiple components to be configured at the same time."

Saguna Open-RAN Mobile Edge Computing Platform Powers ACS New Smart Perimeter Enterprise Solution

YOKNEAM, Israel, June 22, 2015 — Saguna Networks, a Mobile Edge Computing pioneer making mobile broadband faster, simpler, and more economical, announced today that the Saguna Open-RAN platform has been selected by Applied Computer Solutions (ACS), a part of the USD 1.5B+ Pivot Group. ACS specializes in integrated solutions that align information technology, processes, and people with business goals. ACS's new Smart Perimeter Enterprise solution leverages Saguna's Mobile Edge Computing (MEC) software solution to provide locally provisioned, value-added voice, data, and video services to small-cell-enabled enterprises.

Synopsys RSoft 2015.06 Release Streamlines Design of Photonic Devices, Photonic Circuits, and Fiber Optic Systems

MOUNTAIN VIEW, California, USA, June 18, 2015 — Synopsys, Inc. (Nasdaq: SNPS) today announced the release of version 2015.06 of the RSoft product portfolio, the company's industry-leading family of software tools for photonic component and optical communication system design. The RSoft Photonic Component Design Suite delivers advanced Finite-Difference Time-Domain (FDTD) simulation features as well as significant speed and usability improvements. The RSoft Photonic System Design Suite includes new libraries of components and algorithms to streamline the design of photonic chips, modulator circuits, and coherent transceivers, as well as an innovative new platform for modeling large-core multimode fibers. The enhancements in version 2015.06 facilitate faster, more efficient design of a wide range of current and emerging photonic devices, photonic circuits and fiber-based applications.

Internet2 Implements First Large-scale Deployment of ONOS in Live Network

WASHINGTON, District of Columbia, USA, June 15, 2015 — Internet2, the Open source SDN Network Operating System (ONOS) community, and the Internet2 NOC at Indiana University today announced they have actively deployed ONOS on Internet2's nationwide Research and Education (R&E) network. Five higher education institutions — Duke University, Florida International University, the Indiana GigaPoP, MAX, and the University of Maryland-College Park, and the University of Utah — are connected to a virtual slice of the Internet2 nation-wide network that is piloting this next-generation advanced network technology.

"This is a major milestone in the SDN era," said Rob Vietzke, Vice President of network services at Internet2. "We are pleased to partner with the ONOS project team to deploy this breakout, software-defined capability for the first time on a nation-wide production network. This work is a notable contribution from the R&E community in efforts to explore new research ideas in the field of networking and create prototype services that will influence the next generation of the Internet."

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Ren Zhipeng

FusionCloud for Enterprise Transformation

| **By** *Ren Zhipeng, President, Huawei Cloud Computing Product Line*

Accelerated strategic IT transformation offers enterprises more efficient ways to meet the demands of interacting with their customers and other businesses. >>

Cloud computing continues to gain acceptance among enterprises, and not all enterprises are at the same stage of IT transformation. Even when two enterprises are at the same stage of technical progression, they may face very different challenges. Huawei has developed the FusionCloud engine to minimize these types of transformation issues by using a converged, open architecture that supports public, private, and hybrid clouds.

Among the many strengths of cloud computing is the freedom for enterprise IT departments to derail rising costs and lift capacity limits by enabling increased scalability, flexibility, and efficiency of their IT platforms. Further, cloud computing solutions enable enterprises to treat their IT resources as a service, with concurrent direct access from each and every business department. The "resources as a service" mode affects business and communication processes internally, and also in interaction with other enterprises and their customers. By adopting cloud computing to facilitate their IT transformation, enterprises are speeding up the strategic transformations necessary to adapt to rapidly changing, uncertain external markets.

Huawei FusionCloud allows enterprises to easily and flexibly update critical businesses processes to fit shifts in the market. The results are higher efficiencies, reductions in the amount of investment and manpower needed for IT build-outs and management, and the promotion of continuous production mode innovations that ensure long-term competitiveness.

Converged and Open Clouds

● Infrastructure Consolidation
Traditional infrastructure architectures are relatively inflexible. Despite the growing use of virtualization technologies, resource pools do not scale well and are isolated from each other. The result is that enterprises find it difficult to synchronize the infrastructure development with their business growth while

also keeping maintenance costs in check. To address this situation, Huawei has developed FusionSphere, a cloud operating system that helps data center system administrators improve infrastructure management. Based on OpenStack, FusionSphere is an open scheduling and management framework that integrates multiple resource islands. With FusionSphere, enterprises can integrate and share various enterprise-infrastructure IT resources, including virtualization solutions such as Huawei's FusionCompute and VMware, and bare-metal physical servers. FusionSphere-equipped servers — physical and virtual — can share the same software-defined storage and network resource pools via a unified Application Programming Interface (API) and integrated resource pools built to support automated and on-demand activities.

The Huawei FusionCloud solution is based on distributed cloud management and scheduling software. It implements logical integration of IT infrastructure resources across servers, resource pools, data centers, and boundaries between private and public clouds. Using unified cloud service catalogs and service APIs, Huawei FusionCloud provides Infrastructure-as-a-Service (IaaS) to upper-layer applications that support elastic capacity expansion and flexible deployment of services based on tenant loads.

● Application Integration
Huawei FusionStage is a Platform-as-a-Service (PaaS) solution to help IT departments and enterprise software developers to implement management integration applications across the business lifecycle. FusionStage is based on Cloud Foundry, and the Docker OS-level virtualization architecture for micro-service application deployment, to reduce complexity, development cost, and operating cost. Other techniques, such as elastic scaling and gated application launches, are used to help enterprises innovate to levels comparable to those of major Internet providers. The FusionStage management platform integrates

development, testing, and production functions, as well as unifying the environments, tools, and processes that accelerate service rollouts.

● Data Convergence
Decision-makers can improve their understanding and management of enterprise data using Huawei's FusionInsight Big Data platform, which converges data by integrating data islands. FusionInsight provides Big Data intelligent mining and analysis software that allows enterprises to extract value metrics from data for identifying commercial growth points. FusionInsight's automated, browser-based O&M greatly lowers the difficulty of deploying and managing Big Data services — and is the first platform in the industry to support finance-class data protection and geographic disaster recovery between sites separated by more than 1,000 kilometers. Backed by a library of proprietary deep learning algorithms, FusionInsight is engineered to perform millions of levels of pattern recognition, inference, and deduction.

Huawei FusionCloud uses the following engines:
· FusionSphere: Operating system for infrastructure consolidation based on the commercial editions of OpenStack, KVM, and Xen.
· FusionInsight: Big Data platform for data convergence based on the commercial editions of Apache Hadoop and Apache Spark.
· FusionStage: PaaS platform for application integration based on the commercial editions of Cloud Foundry and Docker.

Huawei has applied its understanding of open-source software architectures and program code to enhance reliability, usability, maintenance, security, and performance. Open-source software modules are selected for their support of large-scale commercial deployments; and system tests are built to identify and remove system stability risks.

Huawei ranks seventh in OpenStack community contributions, and fourth in Hadoop community contributions. Initially limited to new code and reviews, Huawei has become

involved in projects such as the OpenStack cascading project to solve the challenges and difficulties OpenStack encounters in resource scalability and multi-site unified management at the architectural level — a project that has received wide support from global telecom carriers. In the area of open-source containers, Huawei is a founding member of the Open Container Initiative (OCI) and Cloud Native Computing Foundation (CNCF). In August 2015, Huawei announced the open-source Astro project to push for the wider application of the Spark SQL in the Big Data industry.

The FusionCloud solution involves three major application scenarios: private cloud, public cloud, and carrier-grade Network Functions Virtualization Infrastructure (NFVI). The FusionCloud solution reduces the complexity of cloud infrastructure deployments for customers who wish to leverage the cost of data acquisition into added value.

Private Clouds Transform Enterprise Businesses

Cloud computing has become a primary platform for modern enterprises that invest heavily in IT transformation for competitive advantage. In the financial services industry, Internet-accessible products have created a serious challenge to conventional banks and lending institutions. Increasingly — driven by volumes of mobile transaction data — legacy providers are improving the quality of their decision-making for everything from user experience to market position based on Big Data analytics. The result is that traditional IT architectures and data processing platforms have to be restructured, existing IT frameworks fine-tuned, and unified data management procedures implemented in order to achieve faster service rollouts.

In partnership with China Merchants Bank (CMB), Huawei has established a scalable
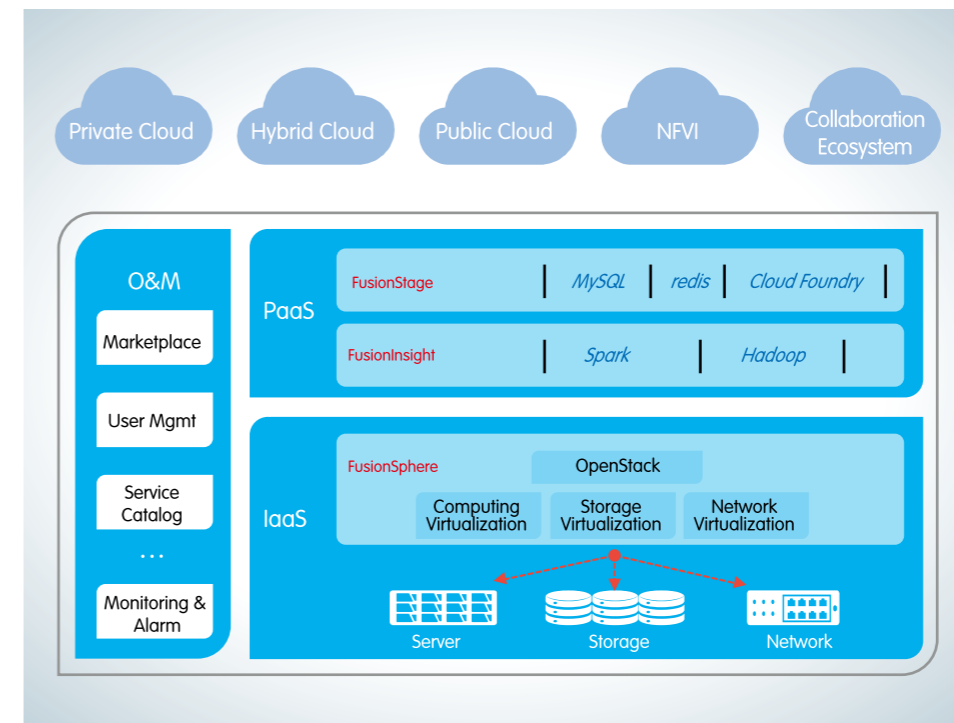
Huawei FusionCloud Solution Architecture

IaaS platform that meets CMB's Internet banking requirements for resource elasticity and scalability. Using Big Data technology, Huawei has helped CMB improve the operating efficiency of its traditional businesses and encouraged them to explore new opportunities. For instance, in the past, CBM's online query service for credit card transactions was limited to a 13-month history; with the Huawei solution, CMB customers can query their transaction histories back seven years.

In the government sector, Huawei has worked closely with China's General Administration of Customs (GAC) on the "Golden Customs" project to deploy a distributed cloud infrastructure with data centers in Beijing, Guangzhou, and Shanghai to accommodate customs IT applications.

Public Clouds Create New Business Opportunities

As public clouds become more popular with

NFVI technologies are considered by many to be foundational to satisfy the exacting requirements for future telecom networks. Huawei has conducted joint NFVI innovation and business verification tests with several leading telecom carriers. >>

small- and medium-sized enterprises, many companies are choosing to lease rather than buy their IT systems.

To adapt to this trend, telecom carriers are increasing their capabilities to provide public cloud services. As a long-time partner of telecom carriers, Huawei is a cloud service enabler that is helping telecom carriers take best advantage of network bandwidth, localized services, and established enterprise user base to deliver a broad array of benefits to end users.

In June 2015, Deutsche Telekom (DT) chose to partner with Huawei to create a win-win paradigm for a public cloud service. In compliance with strict European Union (EU) data protection policies, DT data centers in Germany provide much needed cloud services to small- and medium-sized enterprises throughout Europe, as well as to VIP customers in the government sector and large enterprises. The Huawei cloud

service includes IT hosting and hybrid service with interworking between private and public clouds that allows all parties to pool their advantages for better business results.

NFVI for Telecom Clouds

Telecom carriers need a future-oriented network architecture to overcome the legacy physical networks of dedicated hardware devices that, because they are closed systems, are fundamentally incapable of meeting the modern requirement for quick and flexible service deployments.

NFVI technologies are considered by many to be foundational to satisfy the exacting requirements for future telecom networks.

The core of NFVI is virtualization and cloudification of telecommunication systems. Aided by Software-Defined Networking (SDN), NFVI enables telecom carriers to construct networks that are open, intelligent, and agile. The goal is to help telecom carriers greatly improve business efficiencies by adding elastic and dynamically scalable resource pools that provide immediate benefits in the areas of construction and O&M cost reductions. Huawei has conducted joint NFVI innovation and business verification tests with several leading telecom carriers, including Telefonica, America Movil, DT, China Mobile Communications Corporation (CMCC), and Megafon.

Huawei and Telefonica began co-operating in the NFVI domain in August 2012, when the two parties discussed the construction of a virtualized cloud-based telecommunications architecture to realize their next-generation ICT transformation. Called Project UNICA, Telefonica's goal is to form a single virtual data center for efficient sharing between internal departments and subnets. Following a number of joint network planning and Proof-of-Concept (PoC) activities, in July 2014, Telefonica announced that Huawei won the bid for its UK subnet project and the first commercial deployment of the UNICA architecture.

Enterprises need diversified products and services to help them transform their IT architectures. To provide the widest range of available solutions, Huawei maintains close collaborations with hundreds of technology partners in the cloud computing field. >>

Partners Build Ecosystems

Enterprises need diversified products and services to help them transform their IT architectures. To provide the widest range of available solutions, Huawei maintains close collaborations with hundreds of technology partners in the cloud computing field, including:

• Intel — Cloud computing performance optimization and trusted computing.
• SAP — Database and cloud service.
• Accenture — Cloud computing solutions.
• IBM — Database and middleware.
• Microsoft/Red Hat/SUSE — Operating systems and enterprise applications.
• SAS — Big Data.
• Trend Technologies and Beijing Rising Technology — Cloud security.
• NVIDIA — Media and manufacturing cloud.

The Huawei cloud computing team provides channel partners and Independent Software Vendors (ISVs) with pre-sales training, certification, and delivery capabilities training. Custom solutions are certificated though the "*Huawei Ready*" online virtual lab.

For channel partners and ISV talent, Huawei has established strong ties with universities and training institutions worldwide in cloud computing. In this way, Huawei is demonstrating a long-term commitment in developing the technical proficiency to provide the upper-layer applications necessary to maximize the use of Huawei's cloud computing platform. Talented personnel in cloud computing are an essential key link for the continuing success of our partners and the customers we share.

A sound cloud computing ecosystem, based on open systems and widespread collaborations across industries, will create the necessary environment for all parties to promptly respond to market changes, stay competitive, and improve business performance in an uncertain future. ▲

William Xu

Huawei Global Connectivity Index: Benchmarking the Transformation to a Digital Economy

| By *William Xu, Huawei Chief Strategy Marketing Officer*

Huawei's Global Connectivity Index (GCI) quantifies the connectivity status of different countries with a comprehensive, objective, and scientific calculation of the value generated by transforming into a digital economy. >>

The strategy for transforming into a digital economy must be carefully planned and executed. With full insight into the ICT industry, powerful planning capabilities, and extensive global project experience, Huawei is actively helping many countries around the world achieve their digital transformation goals. >>

The impact of the digital economy is transforming every country around the world whether they like it or not. "Get on board or get left behind" is a hard fact to face for countries under pressure to accelerate their social and economic development and improve their competitiveness. A primary element of this process is connectivity — which also happens to be Huawei's core business proposition.

Tide of Digital Transformation

A "Better Connected World" is emerging. Huawei is forecasting that by 2025, there will be 100 billion digital connections and the global market for the Internet of Things (IoT) will be worth USD 2 trillion. The rapid proliferation of broadband, cloud computing, and Big Data analytics are combining with many other significant technology changes to create an Information and Communications Technology (ICT) environment that is enabling the IoT to rise and become a key disruptive force in our economic lifetimes, for countries, industries, and individuals alike.

In fact, several major countries have already embarked on the race, leveraging ICT technologies to either sustain their competitiveness or get ahead of the curve for the coming connected age — "Made in China 2025," "Industry 4.0" in Germany, and America's "Industrial Internet" — just to name a few — all represent different approaches for similar ambitions. Digital transformation is the engine driving the world into a new era of ICT-centered economic activity. Any country that fails to keep pace is destined to lag behind in international competition for decades to come.

This digital transformation requires the participation of players across industries, and for which electronic connectivity is the single most important key for bridging the physical world with the digital world. Peripheral mobile devices and sensors will connect with core data centers to form ubiquitous networks. Integrated combinations of ICT technologies, such as network switches, servers, and mass storage create the transformation-enabling foundation necessary for transforming traditional IT components into the cloud computing, Big Data analytics, and IoT platforms necessary for the coming sea change.

So how should we evaluate a country's ICT development and its impact on the digital economy? How best to optimize ICT investment to maximize the benefits of the digital transformation? How can we forecast the development priorities and trends for each industry in each national economy?

Huawei's Global Connectivity Index (GCI) quantifies the connectivity status of different countries with a comprehensive, objective, and scientific calculation of the value generated by transforming into a digital economy. The GCI provides an indicator of which countries are best poised for development and growth, and an ICT planning reference for policymakers looking to embrace the digital economy.

Global Ranking

The 2015 edition of the GCI employs a more advanced framework and new methodology from years past. With double the number of ICT variables and countries analyzed compared to last year, the 2015 GCI is able to draw the correlations necessary for governments and other stakeholders to establish appropriate investment targets. A distinguishing feature of the Huawei GCI from similar indices is a broader definition of what constitutes connectivity between networks, computer resources, and storage, while emphasizing the non-infrastructure elements of a fully functioning digital economy, such as service demand and eCommerce activity.

In order for connectivity to reach its full potential it needs to be available, adopted, and provide an inspired experience. In total, 38 indicators divided across Supply, Demand, Experience, and Potential were measured, analyzed, and cross-referenced. The findings of this analysis not only validate expected correlations between technology investment, adoption, and economic growth, but also reveal some

surprising insight around the impact of the five transformation enablers — broadband connectivity, data centers, cloud computing, Big Data, and IoT — as these technologies represent the targets on which stakeholders should focus their investments in order to most efficiently transform their economies for the digital age.

Based on a robust supply and demand of ICT services, and an advanced state of adoption, the United States ranks the highest among surveyed countries. The mature national economies of Sweden, Singapore, Switzerland, and the United Kingdom round out the top five. Chile, China, and the United Arab Emirates (UAE) lead the developing markets, with all three ranking in the high teens to low twenties overall. Developing market leaders are characterized by strong mobile adoption and overall access that is often comparable to developed markets, while typically lagging behind in terms of data center investment and other core elements of ICT infrastructure. Data center investment by developed countries is three times that of developing countries, which is the major catalyst of cloud proliferation as "the edge does not exist without the core."

Overall, the 2015 GCI shows that 20 percent growth in ICT investment will increase a country's GDP by one percent.

Mobilizing for Transformation

The GCI is a useful tool for understanding which stage of development each country is currently in, how it compares with its peers, and how close it is to breaking through into a more advanced stage — or the risk it faces in falling behind. The findings from the GCI are helpful for governments and business leaders to navigate the daunting march toward a digitally transformed economy.

It is Huawei's opinion that governments should lead the way. Governments are in the position of greatest responsibility for assertively pushing for development rather than relying on market forces which may be reactive, have insufficient resources, or have different priorities. One of the best ways for businesses to learn is to lead by example, and governments are uniquely capable of paving the way for businesses and citizens by incorporating technology-based services into its infrastructure for the society at large. Singapore and Canada are good examples of countries where eGovernment has been a major catalyst for promoting mobile applications which, in turn, have provided the impetus for remarkable performance growth in the area of broadband services.

Governments should also further invest in the IoT and Big Data, as every new connection generates a new data source. Network security is an essential component for building a trustworthy, transparent, and cooperative environment for internal and external customers.

Recruiting the best and brightest talent is crucial for the transformation into a digital economy. Governments and businesses must not delay in attracting and developing the necessary human resources for the collective benefit of their local industries and national economies.

The strategy for transforming into a digital economy must be carefully planned and executed. With full insight into the ICT industry, powerful planning capabilities, and extensive global project experience — with a footprint in over 100 countries — Huawei is actively helping many countries around the world achieve their digital transformation goals. We are open to partnering with policymakers and enterprise leaders to identify, harness, and create new digital economy opportunities with the aim of building a "Better Connected World." ▲

Out with the Old: Software Applications Drive New Business Strategies

| By *Marco Cassinadri, Managing Director, Technology Lead, Accenture Greater China*
Hongbiao Yu, Managing Director, Electronics and High Tech Industry, Accenture Greater China

Marco Cassinadri

Hongbiao Yu

Modern enterprise software applications can help businesses seize new opportunities brought by the digital era and open new competitive frontiers. >>

T he pace of technological change is fundamentally disrupting the way we live and work, pushing companies to rethink and reinvent the way they do business through software. In every industry, companies are using software to establish new competitive frontiers, expand into new markets, create seamless customer experiences, and generate new sources of revenue.

Gartner reports shows that new software applications are the driving force for companies aiming to achieve digital transformation and innovation. By 2017, seventy-five percent of new software will be built to meet requirements to achieve digital business goals. The strongest possible conclusion is that the strategy behind any new software application is the single most important tool for reinventing and reinvigorating an existing business, or the creation of a new and disruptive business. The undeniable truth is that modern enterprise software applications can help businesses seize new opportunities brought by the digital era and open new competitive frontiers.

For example, FAW Group Corporation, a Chinese state-owned automotive manufacturing company headquartered in Changchun, Jilin, has launched an Android-based automotive system — inkaNet — that uses the MirrorLink device interoperability standard to enable the connection between vehicles and mobile phones so that smart phone applications (such as navigation) are better optimized to driving environments. The result is a substantial contribution to both convenience and safety. The FAW inkaNet system also supports natural semantic recognition to better predict a wide gamut of individual user intentions without the requirement that each user follows a set of fixed rules for interactions with the device. An additional major benefit of the Android platform is openness: all interested software developers can easily develop applications to run in the inkaNet ecosystem. By demonstrating the ability to show a wide differentiation in car products, new software applications are stretching the competitive frontier for businesses in the transportation sector.

Transforming into a software-driven business is not an easy task for most companies. The fact is that many legacy corporate IT systems are showing their age, with an estimated seventy to eighty percent of today's business transactions processed in COBOL, a computer language that first appeared in 1959. Many companies are trying to compete in the 21st century with applications built decades ago — monolithic applications that took a long time to build and take a long time to change. Modern enterprises need new application strategies to help them accelerate the uplift of their IT systems to meet the pace of today's business climate — not only to sustain their historical advantages, but also to gain important ground on the competition.

Strategy 1: Liquid Applications

In a high-velocity, software-driven world, there is less time for complex, lengthy, and expensive coding of applications, or massive, multi-year system implementations. What is needed is a fundamentally new way to build software — faster, flexible, and more "liquid"— by rapidly assembling reusable components that meet the needs of endlessly shifting business environments.

Liquid applications apply modular architectures, next-generation integration techniques, and a cloud-first and mobile-first mindset. When combined with engineering development innovations such as Agile and DevOps, modular architectures enable the continuous delivery of software that evolves as business needs change. The big shift is from monolithic applications to a world of smaller components and service modules.

Liquid applications require enterprises to create modular architectures featuring reusable components that can be sourced internally or externally. Emerging Platform-as-a-Service (PaaS) environments provide well-defined technical architectures that include interface standards, governance, and reusable code. The result is the rapid creation and assembly of cloud-first and mobile-first business applications that are engineered to operate at scale and designed for easy interaction by customers and employees alike.

Strategy 2: Intelligent Applications

To manage growing volume, velocity, and complexity — and maximize the business value of internal and external data — companies are embedding software intelligence everywhere. Advances in computer science, such as increased processing power, innovations in natural language processing, machine learning, and cognitive computing lead to software intelligence. Based on these breakthroughs, software is taught to automate decision-making through rule-based algorithms, and to evolve and innovate based on recursive learning techniques. Intelligent applications offer three critical capabilities:

The first is Intelligent Automation. By automating routine tasks, intelligent applications offload complexity and supplement human effort through technologies such as auto-correction and robotics. Intelligent automation improves productivity by doing more work in a fraction of the time with greater accuracy. The second is Integrated Analytics, which creates systems that can sense, assess, and respond to the data inputs and outputs of embedded business processes to deliver radically improved performance. The third capability is Self-Governance. Through the use of digital agents, intelligent applications can be taught to learn and govern themselves which, in turn, can revolutionize customer service, infrastructure management, and business innovation.

Strategy 3: Connected Applications

To grow revenue and defend their market position, companies need to create new competitive frontiers using software. Doing so requires opening multiple dimensions of application connectivity. Connected applications offer companies the technical means to dynamically interface with the Internet of Things (IoT) and with business partner and customer ecosystems. As the IoT matures, connected applications will run everywhere — not just on traditional hardware such as phones, tablets, and PCs, but also in manufacturing, pipelines, industrial equipment, cars, wearables, and more — to convert products into connected product-service hybrids.

These applications change the way companies operate by opening up their manufacturing operations, production facilities, products, and services to new technologies. Connected applications are also required to dynamically interface with business partner and customer ecosystems in today's highly networked, digital business environment. When properly designed and managed, each ecosystem multiplies the power of all the participants, leading to new combinations of functionality — and new revenue opportunities — that would have been difficult to achieve otherwise.

Both groups need to understand how modern software can spur growth, shape new markets, and reach new customers. Business and IT must work together closely to orchestrate innovative products and solutions. >>

Are you ready to take the lead?
These three new application strategies also depend on embracing an entirely new operating model for software development, encompassing customized Enterprise Resource Planning (ERP) and Software-as-a-Service (SaaS). For many companies, the legacy model for IT operations is neither suitable nor sufficient for today's high-velocity business environment. Going forward, IT managers must be prepared to define and execute new business strategies through new software. In all cases, businesses must strive to gain technical insight and a vision that assumes a prominent role for building modern software. Innovations must be strategic, and driven by joint planning processes that span both the business and IT.

Complete comprehension entails an understanding — by both the business and IT teams — of what it means to be a software-driven business. Both groups need to understand how modern software can spur growth, shape new markets, and reach new customers. Business and IT must work together closely to orchestrate innovative products and solutions. When long-term competitive advantage is at risk, being a "fast follower" may not be fast enough.

Are you ready to take the lead? ▲

Service-driven NFV Powered by FusionSphere

Ahtasham Rabbani

| By *Ahtasham Rabbani, Senior Manager, Cloud Marketing, Huawei Technologies, Inc.*

Network Functions Virtualization (NFV) offers industry-standard ways to virtualize a wide variety of functions that combine to implement IT services. >>

Rather than invest in dedicated routers, firewalls, or other special-purpose hardware, network operators can implement these functions with software running on standard NFV Infrastructure (NFVI). NFV leverages IT virtualization technologies to make various types of network devices comply with industry standards. With NFVI in place, operators can run any and all types of NFV-compatible, virtual IT functionality. The functions run on commodity servers and are connected by high-speed switches. Using this approach, network operators can set up a new Virtual Machine (VM) or an entire virtual data center simply by deploying software on the standard infrastructure.

Defined by the NFV standards group under the European Telecommunications Standards Institute (ETSI), a primary NFV advantage is its openness and use of standard hardware, software, and architecture. Because software is decoupled from hardware, network operators have the agility to quickly scale resources up or down. Complementary to Soft-ware-Defined Networking (SDN), NFV offers the ultimate versatility in using networking, computing, and storage resources.

Huawei is implementing NFVI using the company's FusionSphere cloud OS. Huawei's Virtualized Infrastructure Manager (VIM) is a key part of the NFV Management and Orchestration (MANO) domain that manages and schedules all NFVI resources; maps and links service networks with NFVI resources; and implements Operations Support System (OSS) services. FusionSphere is based on OpenStack, the open-source cloud-computing software platform.

The Ultimate Cloud

Conceived as a virtualization platform for telecom service providers, NFV capabilities are also useful for enterprises operating large networks, and especially those with multiple data centers. The underlying servers, switches, and storage devices can be deployed in data centers, on network nodes, or even as part of Customer Premises Equipment (CPE).

In contrast to conventional clouds, NFV systems must explicitly request and define the topology of CPU, memory, and I/O resources by number, proximity, and availability.

NFV advocates think of it as the ultimate cloud architecture.

FusionSphere

Huawei uses the FusionSphere OS to provide a complete NFV management platform. The VIM consists of Huawei OpenStack enterprise edition and FusionManager cloud management system. The enterprise edition of OpenStack — with enhanced reliability, maintainability, and performance — accesses a hypervisor to manage virtual resources and provides standard OpenStack interfaces for third-party integration. FusionManager uses OpenStack northbound interfaces to provide portal functions and native OpenStack interfaces for advanced functions such as service catalogs, capacity management, and fault management.

The Huawei NFVI consists of three parts:

• FusionCompute uses the Linux, open-source Kernel-based Virtual Machine (KVM) to implement compute virtualization.

• FusionStorage virtualization is integrated seamlessly with Cinder, the OpenStack Block Storage service.

• FusionNetwork is an OpenStack-based network virtualization interface that seamlessly integrates with OpenStack's Neutron network abstraction services.

Huawei uses the FusionSphere OS to provide a complete NFV management platform. The Huawei NFVI consists of three parts: FusionCompute, FusionStorage, and FusionNetwork. >>

FusionNetwork supports data plane forwarding to ensure that VM network performance reaches the Network Interface Controller (NIC) line rate. The system supports Virtual Extensible LAN (VxLAN) to increase the number of available Layer 2 networks in the system from 4,096 to 16 million.

Virtual Operating Environment

Versatility is a key aspect of the FusionSphere environment. The Elastic Virtual Switch (EVS) feature brings Virtual Local Area Networks (VLANs) and scalable network functions such as Dynamic Host Configuration Protocol (DHCP) quarantine, bandwidth limiting, and priority settings.

An EVS is deployed on a host to connect host NICs and VM NICs for transmitting data between internal and external networks. EVS port attributes include bandwidth QoS, Layer 2 security, and VLAN Identification.

FusionSphere VMs on the same subnet communicate directly, otherwise via a virtual router. The Huawei solution supports Network-as-a-Service (NaaS) VPN environment for connecting separate networks over a Distributed Virtual Router (DVR) — avoiding Layer 3 traffic detours across the data center — by offloading east-west traffic to the compute node.

FusionSphere also features the ability to perform in-service upgrades without interruption to VM services or networks, as follows:

• The unified upgrade framework enables access to OpenStack, host OS, and hypervisor simultaneously.

• One-click administration tools perform software uploads, VM migrations, system upgrades, confirmations, and rollbacks.

• VMs automatically live-migrated transparently to active services.

• Upgrade procedures include evaluation and confirmation steps to ensure sequential integrity.

FusionSphere leverages OpenStack versatility by centrally managing Application Programming Interface (API) resource pools. A cascaded OpenStack system is able to schedule support for

Versatility is a key aspect of the FusionSphere environment. The EVS feature brings VLANs and scalable network functions such as DHCP quarantine, bandwidth limiting, and priority settings. >>

To meet telecom operator requirements for maximum uptime and data loss prevention, the FusionSphere NFV solution is designed with multiple levels of computing, storage, and network redundancy. >>

up to 10,000 physical servers and 100,000 virtual machines.

Multiple private cloud tenants

Support for multiple tenants is an expected public cloud capability, though may be useful for any large enterprise private cloud. Virtual Data Centers (VDCs) are a straightforward way for each organization in an enterprise to deliver the differentiated functionality.

The Huawei VDC service provides Data Center-as-a-Service (DCaaS) flexibility for public and private cloud tenants across multiple physical data centers. The VDC resource scheduler will select the most suitable user resources by (among others) geography and Service Level Agreement (SLA).

A VDC is a collection of shared computing, storage, and network resources that provide the following functions:

• NFV techniques are used to virtualize firewalls, load balancers, Layer 2 and layer 3 network devices, DHCP servers, and other VPN devices.

• VDCs make it practical to allocate and secure discrete and isolated compute, storage, and network resources by organization or client.

• Virtual resource allocation can be measured, managed, and traced based on their level of use.

• VDC technology simplifies IT systems by providing automated self-service for VM management and firewall configuration on a unified portal.

Each tenant owns their own private service catalog, global resource view, and independent service approval process. Tenants may also assign development, test, and production departments to different VDCs to guarantee resource isolation and faster on-line services.

FusionSphere resources can be allocated to multiple tenants for own unique pub-

lic cloud deployments. Tenants can specify and manage their own on-demand resources from the available pool — an advantage for cloud service resellers able to shed VDC Operations and Maintenance (O&M) costs.

Designed for Reliability and Security

To meet telecom operator requirements for maximum uptime and data loss prevention, the FusionSphere NFV solution is designed with multiple levels of computing, storage, and network redundancy.

An OpenStack High Availability (HA) implementation uses active/active or active/standby modes for ensuring reliability. OpenStack ensures database and communications service reliability by providing continuing access to Representational State Transfer (RESTful) API services.

The FusionSphere feature-set employs multiple methods to achieve carrier-grade network and VM continuity.

If a VM is faulty, FusionSphere will first attempt to restart the VM on the local server. Should this fail, the VM will be automatically restarted on an available external server with free space. If a physical node has failed, FusionSphere will automatically restart all affected HA-enabled VMs on other space-available compute nodes. To help O&M personnel locate and rectify complex faults, FusionSphere provides black box, logging, and alarm reporting functions. FusionSphere allows for upgrades and other scheduled maintenance in ways that do not interrupt services.

Carrier-grade network communications reliability is achieved using a multi-plane system that separates management, storage, service, and Intelligent Platform Management Interface (IPMI) functions over discrete VLANs. The management plane transmits RESTful and Remote Procedure Call (RPC) messages between service nodes, and IPMI transmits server management messages.

For data loss prevention, FusionSphere makes multiple copies of program data, metadata, and service data, and ensures its reliability with automated error correction and restoration.

Furthermore, Huawei's experience with virtualized cloud computing environments provides the basis for meeting specialized, multi-tenant NFVI security needs.

With hardware and software expertise in telecommunications, IP networking, servers, and storage systems, Huawei is the ideal NFVI provider.

Based on 20 years of experience in telecommunications software, Huawei's Business Support Systems and Operating Support Systems (BSS/OSS) have been implemented at more than 400 carrier sites around the world. As an OpenStack Gold Member, and a top-20 OpenStack code contributor, Huawei is setting the stage for NFVI to represent the future of telecommunications and possibly all enterprise IT.▲

Liu Hao

Unleashing IT Values, Keeping Telco DNA

| By *Liu Hao, Sr. Manager of Core Network Marketing, Huawei Technologies, Inc.*

The Huawei CloudCore solution for telecommunication carriers have adapted technical concepts from enterprise data center operators. >>

Telecom Operators Adopt IT Technologies

As the mobile Internet becomes increasingly widespread throughout the digital economy, traditional communications services such as voice and text messaging are continuously affected by Over-The-Top (OTT) applications such as WeChat, WhatsApp, and Skype. The smartphone market continues to spawn thousands and thousands of OTT applications, each of which increases the competitive pressure faced by telecommunications (telecom) operators to produce high-quality user experience and more attractive new applications.

New competition and new user experiences and behaviors require that operators make changes to their business, marketing, R&D, operation, and service models. These changes require the support of agile IT telecom networks that are substantially similar to enterprise data centers.

Historically, service innovations in carrier networks have been time consuming and expensive. Traditional telecom networks are silo networks and Capital Expenditure (CAPEX) and Operation Expenditures (OPEX) are excessively high. In other words, upfront cost has been a major bottleneck for operators' development in the mobile Internet era.

New Enterprise cloud computing technologies are providing the technical basis for restructuring communication networks, and bringing new opportunities for telecom network operators. Within a traditional telecom network plant, the Network Elements (NEs), the software and hardware, are decoupled. However, the paradigm shift of cloud computing technologies is brought about by Network Functions Virtualization (NFV) that both shares and flexibly reallocates resources. For telecoms, the first step in cloudification is to upgrade the core network. Huawei's CloudCore solution is an NFV-based core network upgrade.

Ensuring Core Network Capability

First and foremost, the switching and control center of a cloud-based carrier-grade network must satisfy the highest service level requirements for reliability, performance, and self-healing faults.

Following Huawei's ROADS (Real Time, On Demand, All Online, DIY, and Social) predicate, cloud-based core networks must be "open" and available for customer modification. This requires that core network processes be deployed using the most efficient software architecture and design practices.

● Building a Cloud-aware Architecture

Cloud-aware software architecture is essential to CloudCore network capabilities. Cloud software architecture must ensure that telecom software is deployed layer-by-layer — service distribution, service processing, data storage, etc. — in order to keep service logic separate from session data. A stateless design for service processing units also is necessary.

・ The CloudCore system architecture specifies that communications session data be separated from service logic such as configuration data, which is stored by dedicated distributed database modules.

・ There is no need for service logic processing programs to store session data.

・ On the front end, service distribution modules perform load distribution.

・ Since service logic processing units do not store session data, there is no need for service distribution modules to distribute messages to specific processing units by user or session; therefore, they can support reconfigurable distribution strategies. For example, fault-tolerance alert messages can be distributed according to the load and health conditions of each processing unit.

A direct benefit of a cloud-aware architecture is the ability to flexibly scale the number of service processing instances. Virtual machine resources for traffic rebalancing are added or released according to traffic fluctuations within a matter of minutes, independent of the number of active sessions.

● Maintaining Carrier-Grade Service Levels

A number of common technical methods are used to ensure Service Level Agreements (SLAs):

・ Multiple-layer reliability.

・ Key Performance Indicator (KPI)-based self-healing.

・ Service queue control.

・ Virtual resource optimization.

・ Heterogeneous resource pools.

Software and hardware are decoupled in CloudCore networks, and the software is separated by layers. Reliability strategies are deployed from the bottom — servers, storage, and networks — to top-layer applications. We employ multiple network adapter redundancy, network adapter bundling, multiple-disk array networking, and a High Availability (HA) applications layer to ensure 99.999 percent reliability over the entire system.

KPI-based health checks and fault self-healing are essential to ensure carrier-grade SLAs. In traditional system fault processes, entire systems are reset after sufficient degra-

New Enterprise cloud computing technologies are providing the technical basis for restructuring communication networks, and bringing new opportunities for telecom network operators. >>

The Huawei CloudCore system is designed to support heterogeneous mixtures of Commercial Off-The-Shelf (COTS) hardware and open-source cloud operating systems such as ONF and ONOS. >>

dation, risking dropped sessions and data loss. The KPI-based health monitoring systems service KPIs in real time and compare current statistics with historical norms. When key KPIs deteriorate to preset thresholds, alarms are generated and automatic recoveries are rapidly invoked based only on specific fault cases.

Service queue traffic control is independent of CPU usage. The resource load — CPU, dynamic memory, and message packages — is a latency factor that delays clearing each message queue. When resource use is high, the number of traffic control queue service messages are reduced, which in turn increases service message delay and the size of the queue. When the service message quantity or delay exceeds a defined threshold, messages will overflow the queue and trigger traffic control, resulting in an improved CPU utilization.

NFV performance deteriorates because scheduling management and virtual machine interrupts consume system resources — by 20 to 30 percent in extreme scenarios. Optimal software design is the only solution. Virtual machine scheduling (computation and storage) and memory access efficiency are the key factors for improving run-time efficiency. Virtual storage performance is improved through Raw Device Mapping (RDM), a VMware resource that enables the mapping between a virtual machine and a Storage Area Network (SAN). Virtual network performance is improved by reducing I/O interrupts and reducing data copies between the "OS kernel" and the "User modes" of the Intel® Data Plane Development Kit (DPDK).

● Openness

The Huawei CloudCore system is designed

to support heterogeneous mixtures of Commercial Off-The-Shelf (COTS) hardware and open operating systems such as FusionSphere, VMware, and OpenStack.

Because in the real world traditional core networks and cloud-based networks must coexist, Huawei has built CloudCore to operate side-by-side with legacy telecom switching networks as a virtual instance within a unified resource pool under the control of a single Operations and Maintenance (O&M) process.

In all cases, the goal is to enable traditional telecom networks to compete effectively with OTT players. First and foremost, this is achieved by the delivery of pre-integrated hardware and software products from multiple vendors wrapped in an innovative open-source software solution that preserves and aggregates longstanding industry values.

Core Network Cloudification

● Leading Architecture and Design

The Huawei CloudCore solution encompasses all core network NEs and, therefore, fully complies with the design requirements of a cloud-based core network.

This is due in no small part to Huawei's continuing, substantial contribution to the NFV standards process, primarily through the European Telecommunications Standards Institute (ETSI).

Huawei has joined all nine possible NFV research topics within the ETSI standards organization — with the top position among 348 accepted proposals — and occupies two vice-chairman positions.

● Industry Acknowledgement

Huawei dedication to the CloudCore effort was acknowledged at the 2014 and 2015 IMS World Forum for "*Most Innovative Virtualized IMS Solution*," due to our leading technology, successful pilots, and commercial experience.

With leading architecture and design, great industrial contributions, industry acknowledgement, and mature commercial capabilities, the Huawei CloudCore solution is providing strong support to operators for building new, agile telecom networks that lead the cloudification journey for the core network. >>

● NFV Open Lab

In January, 2015, to satisfy customer demand for pre-integrated solutions, Huawei launched an *NFV Open Lab* in Xi'an, China with three primary responsibilities:

・ Develop a multi-scenario, multi-vendor integration and verification capability. Build a flexible multi-vendor integration and verification platform that includes Big Data analysis, continuous integration, and NFV planning practices to provide reliable data support and decision-making by operators.

・ Perform joint development and quick mutual qualification innovations with industrial organizations, operators, and partners.

・ Build open and cooperative NFV industrial ecosystems with commitments, so far, from more than 150 partners.

● Mature Commercial Capabilities

Huawei CloudCore solution has delivered multiple successful commercial cases, including Vodafone-Italy and the successful delivery of the first commercial cloud IP Multimedia Subsystem (IMS) project in the industry. Huawei provided a cloud-IMS based on third-party servers and a Cloud OS. As primary integrator, Huawei was responsible for the vertical integration of the cloud platform from the bottom layer (COTS hardware and Cloud OS) to top-layer IMS applications software. Huawei completed delivery in short order by leveraging a professional delivery team using efficient integration tools and their extensive integration experience.

With leading architecture and design, great industrial contributions, industry acknowledgement, and mature commercial capabilities, the Huawei CloudCore solution is providing strong support to operators for building new, agile telecom networks that lead the cloudification journey for the core network. ▲
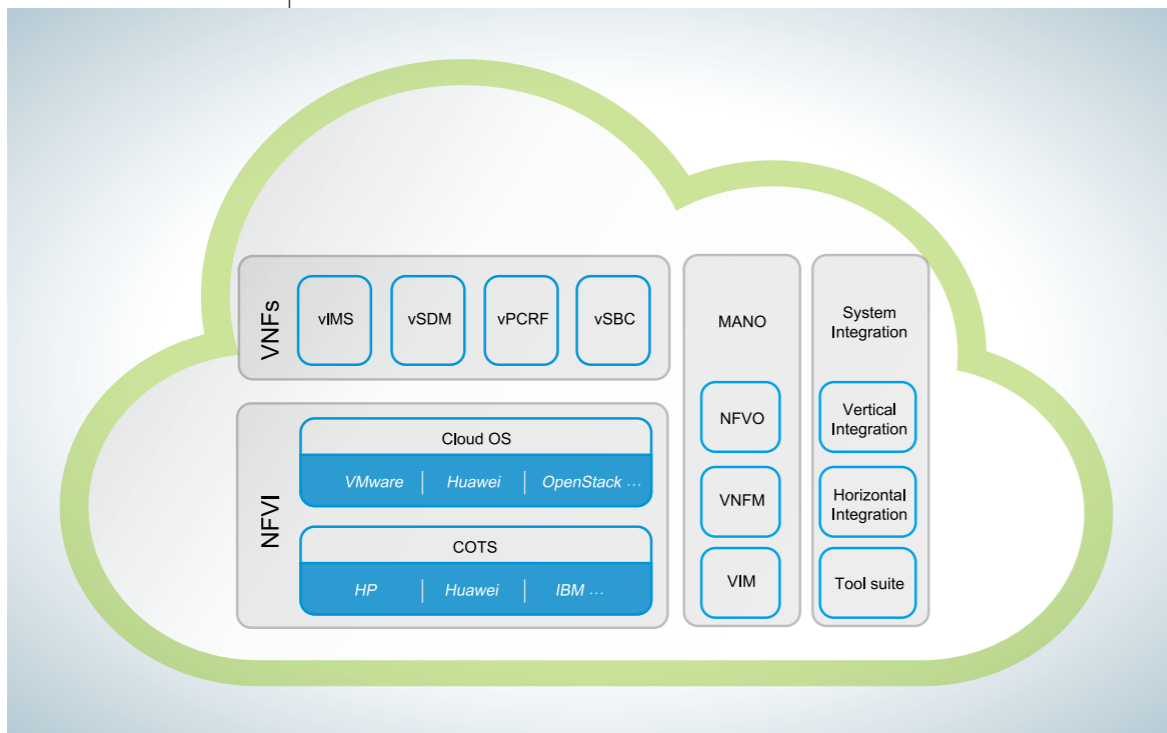
Huawei CloudCore Architecture

Rui Huang

CloudEdge is Driving Mobile Broadband

| By *Rui Huang, Senior Marketing Manager, Packet Core Network Support, Huawei Technologies, Inc.*

Network Functions Virtualization is attracting widespread attention and raising many expectations throughout the IT and telecommunication industries. >>

C loudEdge is Huawei's next-generation Mobile Broadband (MBB) core network architecture that combines Network Functions Virtualization (NFV), Software-Defined Networking (SDN), and Service-Oriented Architecture (SOA). By deploying the CloudEdge solution, operators can build open, flexible, and automated next-generation MBB networks that respond to the continuing demand for new services and network flexibility.

"Cloud-Formation" via NFV Services

Driven by the growing interest in network virtualization, NFV has become a must-discuss resource among operators. Against this backdrop, most equipment vendors have directly migrated traditional Evolved Packet Core (EPC) Network Elements (NEs) to virtual platforms. NE virtualization by itself compromises network elasticity due to limited support for scalability, performance, and reliability requirements.

In addition to providing a virtualized Evolved Packet Core (vEPC) component, Huawei's CloudEdge NFV solution includes virtualized Multi-Service Engine (vMSE) and virtualized Unified Intelligence Center (vUIC) components.

Together, vEPC, vMSE, and vUIC are the building blocks for Huawei's NFV-based "Cloud-Formation" method. For operators, the benefit is the ability to initialize internal and external facing services, flexibly and at scale. The result is transformative, as operators need no longer worry about manually responding to extreme workloads in the face of peak network traffic.

Exceeding Operator Requirements

Mobile Network Operators (MNOs) employ many unique tactics for Quality of Service (QoS) assurance.

The vEPC is essential for replacing the underutilized dedicated hardware — provisioned to meet worst-case scenarios, but routinely left idle — for orchestrating end-to-end service-chains of multiple virtual functions.

The vMSE helps resolve a range of 3GPP Gi-LAN, LTE interface pain points on live networks caused by co-existing service engines and software platforms. Results include improved time frames for rolling out new services, reducing the complexity of network capacity expansion, and simplifying service maintenance. The vMSE is engineered to be a third-party aggregation platform that enables Gi-LAN, QoS service software to be quickly deployed.

Third-party vendors only need to optimize and refine services, while resource scheduling, capacity management, and traffic distribution are left to the vMSE platform. New services are deployed as easily as installing a Windows® executable. The vMSE approach dramatically accelerates the time-to-market of any new service. For example, if an enterprise were to need a video acceleration function (see Tencent use-case, below), an operator would easily deploy that function into the enterprise technical plant in a matter of minutes.

The vUIC platform provides API access to MBB network capabilities for third-party OTT service providers and vertical industries. The vUIC platform is a reporting engine, capable of spawning large numbers of new services and designed to collect and report data for further processing and analysis. An example is the storage and analysis of mobile network tracks, scrubbed of personal information, and used 1) to visualize real-time of automobile and truck traffic conditions to populations of local users, as is done today, and 2) to proactively calculate and present optimal alternate routes — a service that is yet to be perfected.

For the entire CloudEdge package:
- Internal services include the ability to initialize contingency policies upon fault detection that, in the background and transparent to end-users, will switch services across multiple data centers.
- Externally, to better cache video files to forever
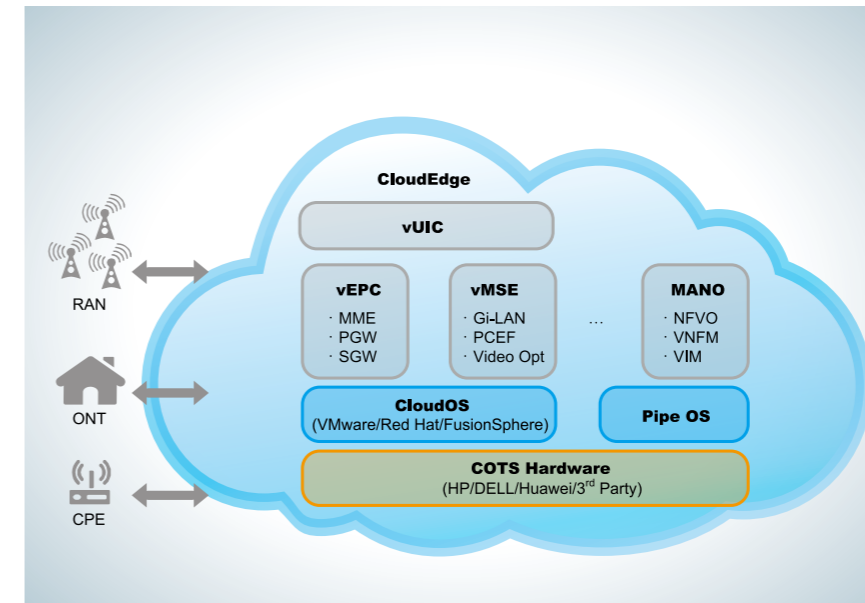
CloudEdge Overview

eliminate the universally familiar start-and-wait behavior known to every mobile Internet user on planet.

From the earliest design phase, Huawei has positioned CloudEdge as a service innovation platform that required the complete virtualization of all EPC, MSE, and UIC functions.

Advancing MBB "Cloud-Formation"

Huawei is organizing NFV open laboratories around the world with the aim of promoting multi-vendor innovation, integration, and verification.
- With acclaim from Tier-1 operators, through Q1-2015, Huawei has completed Proof of Concept (PoC) tests and pre-commercial deployments of CloudEdge in partnership with over 30 leading telcos, including Deutsche Telekom, Vodafone UK, and China Mobile.
- In February 2015, Huawei founded the MBB Interconnect Open Base Lab in Shenzhen and Shanghai to work with the growing industry of OTT service providers and third-party vendors for technical innovation and commercial tests with the understanding that CloudEdge is an important catalyst for MBB network transformation, but alone is insufficient to create large-scale change. The MBB Open Lab exists to help operators create new sources of revenue through updated network architectures and industry eco-systems. The goal is to provide each stakeholder with the opportunity to orchestrate "Blue Ocean" strategies for creating breakthrough markets that are free of competitors.
- Chinese Internet giant Tencent is the first OTT service provider to join the MBB Open Lab, within which they have developed a video acceleration project for its online game "We Fire" that reduces network latency and provides a better game experience. The upgraded "We Fire" platform is currently in commercial use in China Mobile's Guangdong Branch.
- Location-based Big Data analytics are now in commercial use by China Unicom's Shanghai Branch. The availability of time and place correlations provide valuable source data for market research, facilitating accurate forecasts for customer scenarios such as determining retail store locations or evaluating lease values for highway billboards based on automobile traffic. CloudEdge functionality includes the ability to dramatically reduce the cost of data acquisition relative to the increasing degrees of statistical precision.

It is expected that more OTT service providers and third-party partners will join the MBB Interconnection Open Base Lab.

Additionally, Huawei is actively collaborating with international standards organizations and open-source communities to

Faster service rollouts, reduced maintenance, better resource utilization, and enhanced user experiences make the CloudEdge solution an obvious choice to help operators to build a better connected world. >>

drive evolution of industry best practices in innovative technologies such as NFV.
- To date, Huawei is the largest single contributor to the ETSI Industry Specification Group for Network Functions Virtualization (ETSI ISG NFV), with over 236 proposals accepted.
- Dr. Frank Mademann from Huawei has been elected as the chairman of 3GPP SA2.
- Other industry associations in which Huawei is participating include: OPNFV — Platinum Member and Board of Directors; OpenStack — Gold Member; and Open Virtualization Alliance — Supporting Member.

In December 2014, Huawei's CloudEdge solution received the *Total Telecom World Communications Award* for "*Best Infrastructure Initiative*," and, in June 2015, the CloudEdge platform won the "*Best NFV Innovation of the Year*" award at the *2015 LTE World Summit* hosted by Informa.

By combining networking elements that enable operators and third party vendors to build open, flexible, and automated MBB networks, the Huawei CloudEdge solution provides a complete, whole-network management package. Faster service rollouts, reduced maintenance, better resource utilization, and enhanced user experiences make the CloudEdge solution an obvious choice to help operators to build a "Better Connected World." ▲

John Strassner

Huawei's Open Central Office

| By *John Strassner Ph.D., CTO, Software Laboratory, Futurewei Technologies, Inc.*

*Laboratory developments are bringing data center economies to the telecom industry. >>*

Huawei's Central Office initiative is an architectural model now realized in proof-of-concept demonstrations to bring data center economies-of-scale to telecommunications operations. This novel Central Office solution is founded on the use of open source software and open standards to build a scalable and extensible platform for virtual Customer Premise Equipment (vCPE), virtual IP Multimedia Subsystem (vIMS), virtual Broadband Network Gateway (vBNG), and services such as Content Delivery Networks (CDNs) and 4K television. Huawei's Central Office enables new functionality to be gradually phased into systems to support the business needs of each user organization.

Problems and Opportunities

The explosion of unique service types mandates better resource utilization and more freedom to orchestrate network services. Traditional Central Offices are complex collections of hard-wired switching equipment, which makes the introduction of new services a complex and lengthy process. A primary goal of the Huawei Open Central Office is the flexible control of network resources and services.

Key problems faced by Telco service providers include agile service creation, and reducing Operating Expenses (OPEX) and Capital Expenses (CAPEX). One purpose for the Central Office prototype is to demonstrate that combining Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) is an optimal solution for these problems. SDN offers programmability, while NFV separates monolithic functions into sets of agile services. The Central Office initiative is using SDN and NFV to move the traditional telephone company functionality to cloud-enabled data centers. The result is the transformation of switching to a hosted service that, in turn, enables the reallocation of strategic assets. Together, SDN and NFV provide cloud elasticity for local and regional business customers; i.e., dynamic service function chaining, virtualized functions, support service agility, lower time-to-market, and access to new revenue streams.
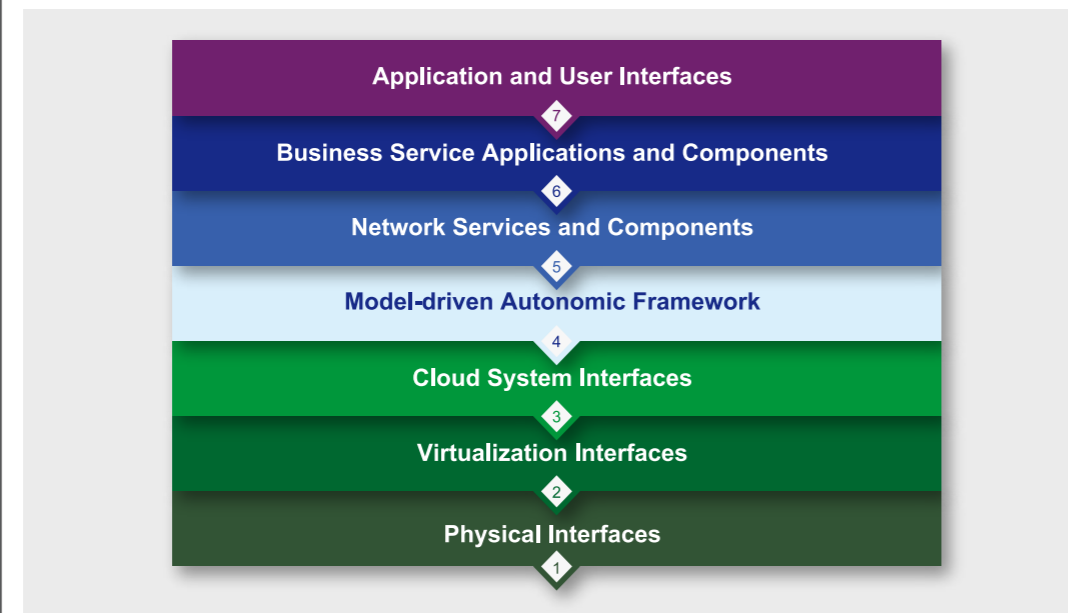
Architecture

SDN and NFV enable the delivery of scalable, flexible, and extensible functionality by implementing virtualized infrastructures under the management of the SDN. The NFV component separates traditional monolithic network functions into agile services based on context-aware policy rules.

The bottom two layers connect "Physical and Virtualization Interfaces" infrastructure through a set of "Cloud System Interfaces" to the "Model-driven Autonomic Framework," which is the "brains" of the Central Office. The autonomic framework — modeled after established data center methods — contains an abstraction of all physical and virtual processing, storage, and network entities that opens the interface to all upper-level applications and services.

The Cloud System interfaces are an explicit example of Huawei's commitment to open software systems. Open standards, such as Open Networking Laboratory's carrier-grade SDN network operating system, ONOS, and OpenDayLight (ODL), are combined with cloud operating systems, such as OpenStack, to provide a comprehensive and holistic solution. The "southbound" interfaces of the Cloud System enable different types of virtual systems (i.e. bare metal Kernal-based Virtual Machines (KVM) systems or packaged solutions such as Huawei's FusionSphere) to be used. Central Office enables either an ONOS or OpenDayLight controller to be used without changing any other components in the architecture. Similarly, the "northbound" interfaces of the Cloud System connect the raw functionality provided by physical and virtual components to a cloud system, such as OpenStack.

The heart of the Central Office system is the model-driven autonomic

Huawei's Central Office platform design goals include support for gradual, step-wise transformations from traditional central offices into dynamic cloud data centers. Central Office is built to allow developers to seamlessly integrate legacy, NFV, and SDN technologies under an orchestrated, policy-driven management framework. >>

framework that uses a common syntax and semantics for different operational, management, and performance data types to be understood by a unified controller. Big Data analytics are integrated into the system control loop to track service degradations and proactively re-initialize application instances before preset Service Level Agreements (SLAs) are violated. The rate at which resources can adapt to changing user needs, traffic loads, business goals, and environmental conditions is improving. Huawei will provide core value-added services, such as service orchestration, real-time traffic analysis, and other Operations Support Systems/Business Support Systems (OSS/BSS) functions. And, because the Central Office architecture is open and modular, operators will be able to purchase or develop their own third party solutions.

The "Network Services and Components" and "Business Service Applications and Components" layers create resource and service building blocks from the framework model. These building blocks form re-usable templates for building system-level services — i.e. load balancing, firewalls, Deep Packet Inspection, and traffic steering. Policy

rules orchestrate how these building blocks create higher-level business services, such as Level 3 Virtual Private Networks (L3 VPN), virtual Enterprise-Customer Premises Equipment (vE-CPE), vCDN, and 4K television for internal and end-user consumption.

The "Application and User Interfaces" layer of Central Office provides graphical and textual access to all functionality through the RESTful API. New policy language interfaces will be added to provide traditional as well as intent-based policies in the near future.

Business Benefits

Huawei is combining open-source software and open standards with modern operations practices to provide an extensible platform that will drive network resources and business services, contextually — time-to-market accelerations, resource and functional agility, and OPEX reductions addressed dynamically in a coordinated and scalable manner.

Huawei's Central Office platform design goals include support for gradual, step-wise transformations into dynamic cloud data centers. Central Office is built to allow developers to seamlessly integrate legacy, NFV, and SDN technologies under an orchestrated, policy-driven management framework.

Huawei plans to demonstrate progressive use cases over the next few months, starting with L3 VPN and vE-CPE on Commercial Off-The-Shelf (COTS) servers using Open Standards and Open Source.

Looking ahead, Huawei remains committed to open innovation across the business development ecosystem to create greater value for our customers, advance the Information and Communications Technology (ICT) industry, and contribute to building a better connected world. ▲

Mao Feixiang

Connecting eLTE and TETRA to Build Smarter Cities

| By *Mao Feixiang, Enterprise Marketing Support, Wireless BU, Huawei Technologies, Inc.*

Fast, multi-dimensional data services are the future of public safety. >>

From Old to New

Since its introduction in the 1990s, Terrestrial Trunked Radio (TETRA) has become the most widely-deployed emergency communications system in the world, providing basic communications services to organizations in the public safety sector for all command and dispatch requirements. TETRA provides many useful functions, and is a mature and stable system that supports flexible networking, wide coverage, powerful error correction, anti-interference capabilities, and the added advantage of a complete industry chain.

However, new Smart City platforms in the public safety sector are demanding data throughput capabilities that TETRA was never designed to support, with higher bandwidth and lower latencies to manage multimedia transmissions.

There is a surge in demand from urban planning engineers for multimedia visual dispatching services that require real-time video transmission and low-latency access to databases. The current wave of specifications expect that a full-range of new technologies be incorporated into Smart City solutions critical for public safety such as cloud computing, Big Data analytics, Bring Your Own Device (BYOD) connectivity, and Internet of Things (IoT) sensor networks. Support for high-resolution images, two-way video, and high-speed data transmission are above and beyond the scope of the legacy TETRA infrastructure and requires the deployment of a modern broadband wireless platform to cope with the new, higher-performance requirements.

A typical multi-dimensional Public Protection and Disaster Relief (PPDR) command and dispatch system must be built to satisfy:

‧ Basic emergency communication networks for wide radio coverage and voice trunking through multiple, integrated wireless digital networks.

‧ Dedicated wireless multimedia hotspots for multi-dimensional control and management, mobile office facilitation, BYOD, and Geographic Information System (GIS) coordination for public safety departments, including police, fire, and medical rescue.

Comprehensive Smart City solutions necessarily include the capacity to interface and coordinate with urban and regional rail transportation systems. By today's standards, previous generations of train-to-ground communication solutions are vulnerable to crosstalk interference and service disruption due to multiple trackside radio networks, and unable to integrate at either the application or data layer. TETRA networks have typically been used for voice-based dispatch, for both operations and emergency services. Wi-Fi and/or analog wireless data systems have been applied to train-to-ground video and control data transmission. LTE entered the scene to operate Passenger Information Systems (PIS) and Closed Circuit Television (CCTV). In the future, it is expected that the LTE platform will be extended to become a unified communication system by also incorporating control data transmission, or Communication-Based Train Control (CBTC).

eLTE Supports TETRA

Based on 4G LTE standards, Huawei's eLTE is a multimedia, application-oriented, wireless broadband system developed to meet enterprises' demanding requirements for broadband data and a seamless interconnection between TETRA and LTE systems. An eLTE-TETRA interconnection is established either as a Gateway Interconnection or a System Interconnection. Both types enable hybrid user groups across eLTE and TETRA systems, Point-To-Point (P2P) voice calls, and priority traffic preemption.

For a Gateway Interconnection, the Trunk Gateway and TETRA Vehicle-Radio are connected to the eLTE and TETRA terminals, respectively. The Gateway Interconnect enables coordination between systems while ensuring the ability of each node to operate signaling and service processes independently.

The Gateway Interconnection option has resulted in widespread adoption owing to the capacity of the system to provision services with great flexibility.

The System Interconnection option, employs a Software Development Kit (SDK) to meet the needs for project-specific customization. The complete kit includes qualified software frameworks that are matched to compatible hardware platforms and operating systems with standard open interfaces. A pre-integration service suite enables systems integrators to connect the LTE transmission and session layers with upper-layer applications. The result is a system-level interconnection between eLTE and TETRA that provisions a wide range of reliable trunking services with high-levels of service capacity and the unified management of complex services.

eLTE Smart City Projects

The recently deployed municipal network in Nanjing, China, is the world's first LTE-

An eLTE-TETRA interconnection is established either as a Gateway Interconnection or a System Interconnection. Both types enable hybrid user groups across eLTE and TETRA systems, Point-To-Point (P2P) voice calls, and priority traffic preemption. >>

based, dedicated broadband trunking network for government. Nanjing had been operating a TETRA voice trunking system and chose to meet growing information processing demands within the public sector with an eLTE overlay.

The Nanjing investment focused on deploying a single, hybrid network that protected the sunk cost of the TETRA platform while adding LTE capacity to implement an advanced data plant capable of scaling well beyond the first generation of smart applications.

Interoperability between the TETRA and eLTE networks was achieved by employing a Gateway and System Interconnection hybrid that supports group and P2P voice calls, two-way multimedia command and dispatch, and priority preemption functions that are operated from either side of the combined eLTE and TETRA network.

Among the services employed by the Nanjing city government is a unified information platform for real-time monitoring and cross-departmental exchange of electricity and hydrological data, and video surveillance of the city's transportation system and mobile offices. System capacity was tested early at the 2013 Asian Youth Games and 2014 Youth Olympic Games.

In the urban rail sector, "Line 1" of the Zhengzhou subway system installed a TETRA network for voice command and vehicle dispatching, and an eLTE platform for dedicated broadband data services, including PIS and real-time train-to-ground video streaming to the command and control center.

Huawei is actively working with partners in the rail transportation sector, including Alstom S.A., headquartered in Levallois-Perret, France, to conduct tests on LTE-based CBTC solutions. CBTC functions on an eLTE platform present operators the opportunity for significant cost savings and synergies in our new era of wireless broadband communications. ▲

eLTE Industry Alliance Update

Norman Frisch

| By *Norman Frisch, Senior Marketing Director, Huawei Technologies, Inc.*

The eLTE Industry Alliance (Alliance) is dedicated to promoting standardization of broadband trunking technology. >>

Founded in Nanjing, China in February 2014, the Alliance has established a global partner ecosystem that includes Independent Software Vendors (ISVs), Independent Hardware Vendors (IHVs), system integrators, consulting institutes, standards organizations, customers, and Value-Added Partners (VAPs). Now into our second year, the Alliance continues to attract new members thanks to a continued strong eLTE market growth and our partners' extensive experience from across industries with a variety of custom end-to-end solutions for a wide range of customers from government agencies, enterprises, and other sectors.

The Latest Update of Alliance

During the 3rd *eLTE Industry Alliance Summit*, held May, 2015 in Barcelona, Spain — attended by seventy-two member organizations — the first eLTE Industry Alliance Steering Committee was formed, including representation from Huawei (Chairperson), Funkwerk, Jiaxun Feihong, Siemens CVC, TD Tech, and UK Broadband.

The goal of the Alliance is to support the rapid development of broadband trunking across governments, public security, transportation, energy, and other vertical industries, including:

· Compliance with existing and future 3rd-Generation Partnership Project (3GPP) international standards that are currently under development.

· Co-ordination with the TETRA + Critical Communication Association (TCCA) for standardizing 3GPP broadband trunking technologies.

· Proactively exploring LTE-Machine (LTE-M), LTE-Vehicle (LTE-V), and LTE-Unlicensed (LTE-U) technologies across industries.

eLTE Industry Alliance Member Success Stories

● Nanjing Municipal Network

Nanjing Commway Communications (NCC) delivered an integrated mobile broadband wireless public administration platform in Nanjing, China. Working with Huawei to construct the Nanjing Municipal Network, NCC provided a unified, eLTE-based command and communication solution to support a wide range of public safety services

including visualized dispatch, remote monitoring of electrical and water infrastructure, video surveillance of transportation lines and key locations throughout the city, and mobile office functions. The Nanjing network was the world's first LTE-based municipal broadband trunking network, and also the first to seamlessly integrate with the existing TETRA network that was already in operational use. In August 2013, Nanjing's eLTE network was instrumental to the success of the *Second Asian Youth Games* and, after a year of further improvements, helped again to support the *2014 Youth Olympic Games*.

The *2015 Business Service Innovation Award* was presented by Global Telecoms Business (GTB) in recognition of the Nanjing municipal broadband network for Huawei's continuing contributions to the development and innovation of LTE technology for the critical telecommunications industry.

● UK Private Broadband

UK Broadband is a British wireless broadband provider that offers professional mobile communication and wireless broadband access services for government, telecommunication, and institutional partners in the UK. UK Broadband and Huawei partnered to construct multiple, private eLTE networks for system integrators, value-added service providers, and strategic partners for which UK Broadband provided frequency bands and services and Huawei packaged the wireless products and solutions. Leaders in the critical communications market in Europe, UK Broadband and Huawei have developed eLTE-specific applications for government and public affairs, intelligent transportation systems, and other large-scale enterprises.

● Public Security in Kenya

Shanghai DS Communication Co., Ltd. worked with the Huawei Open eLTE Laboratory to develop, test, and integrate a full array of cutting-edge command center solutions that have been successfully provisioned in multiple countries, including Kenya, Ghana, and Laos. Integrated within each deployed system is an eLTE private network communications system that incorporates emergency dispatch, Geographic Information System (GIS), crisis analysis, contingency plan management, IP Contact

With the consolidated support of 3GPP and TCCA, the eLTE Industry Alliance expects to make solid contributions to international trunking standards for wider commercialization of hybrid broadband and narrowband critical communications technologies. >>

Center (IPCC), and Interactive Video Services (IVS).

The solution enables Shanghai DS to provide secure, reliable, and unified emergency command services between different departments for the purposes of national security, natural disasters, and civil emergencies.

● Vehicle-mounted eLTE for Shenzhen Metro

Shenzhen Communication Technology Co., Ltd. (SCT) is a system developer and device vendor in the rail transportation sector that covers research and development, manufacturing, and engineering deployment. SCT and Huawei collaborated to develop an End-to-End (E2E), eLTE-based vehicle-mounted terminal for Shenzhen Metro Line 11. The solution supports the Passenger Information System (PIS), Closed-Circuit Television (CCTV), and other vehicle-to-ground communication services. In addition to news and games, the real-time video services include operational monitoring of carriage, cab, and track conditions. The result is the capability for Shenzhen Metro to operate an integrated rail transportation system that delivers stable, secure, and reliable vehicle-to-ground broadband wireless communications.

● GSM-R/LTE Dual-Mode Vehicle Terminal

Huawei and Funkwerk, one of the world's foremost suppliers of railway communication systems based in Kölleda, Germany, jointly launched the world's first GSM-R/eLTE dual-mode, vehicle-mounted terminal for solution for railways. Designed to support voice-based interworking between GSM-R and eLTE modalities, the Huawei-Funkwerk solution also meets the need for railway customers to have real-time vehicle video surveillance, and high-speed data communications for railway technical operations.

The founding of the eLTE Industry Alliance Steering Committee demonstrates the maturity of the Alliance after its first year of activity. With clear goals, the Alliance is building a cohesive partner network with the acknowledgment and support of the industry. With the consolidated support of 3GPP and TCCA, the Alliance expects to make solid contributions to international trunking standards for wider commercialization of hybrid broadband and narrowband critical communications technologies. ▲

Victor Yu

John He

A state-of-the-art public safety platform protects people and property. >>

Building a "Very Safe City"

| By *Victor Yu,Director, Vertical Industry Solution Department, Huawei Technologies, Inc.*
John He, Architect, Government Vertical Industry Solution Department, Huawei Technologies, Inc.

Karamay is a prefecture-level city in the far northwest of China, near the Kazakhstan border. From the Uyghur language, Karamay means "black oil," in reference to the petroleum fields near the city. Over recent decades, Karamay has undergone remarkable changes in economic growth, appearance, government services and city management, and public security.

An oil-producing and refining center, Karamay has made substantial commitments in urban development. Thanks to rapid development funded by the local oil industry, the city has twice been honored as a "Pearl in the Gobi" and a "Beauty in the Desert."

In 2010, the Karamay city government proposed the strategic goal of building a world-class "safe city" of the first order.

Growing Pains
Despite years of continuous investment in ICT-enabled public security, the Karamay city government still faced two major challenges:

First, a low-definition video system failed to fulfill its expected role to support criminal investigations. The surveillance inputs were available only for post-incident backtracking and evidence collection, but ineffective in the area of crime prevention.

Second, the legacy IT system, organized in information silos, could not fully share video files across government agencies. Moreover, key video evidence was occasionally lost due to faults in the video streaming server, further hindering incident investigations.

The overall goals for the video surveillance upgrades were 1) real-time interoperability and 2) reliability.

A Comprehensive Response
Understanding that Karamay's legacy service systems were built separately and independently, priority was given to building a cloud video platform that would be accessible across city government departments — including a video monitoring and analytics solution for the purpose of developing an "early warning" tracking system.

Huawei designed four discreet security surveillance

networks for Karamay: 1) The first network protects the city limits; highway entrances and exits, airports, railways, and buses with High-Definition (HD) cameras and Radio Frequency (RF) terminals for passenger identification, facial recognition, and license plate number registration. 2) The second network is deployed in residential communities using HD cameras and traffic monitors to track people and vehicles passing, entering, and leaving residential communities. 3) Third is the public space network for populated areas such as city squares, scenic spots, and hospitals. 4) The fourth network is deployed at roadway intersections with license plate recognition technology to track and monitor vehicles. Combined, the four security surveillance networks can monitor and track exceptional events and activities.

The Big Data analytics system at the core of the Karamay municipal data plant performs correlation analysis to predict individual behaviors and generate alarms, if necessary, for police response.

Huawei has provided a converged, visualized command solution for government agencies to flexibly share video resources and collaborate in the tracking of suspicious individuals. When incidents do occur, the converged command platform enables a streamlined response from multiple agencies, including police, fire, traffic, and medical services. The converged platform enables personnel to conduct internal video conferences for consultation and decision-making. Police officers in the field use eLTE broadband trunking terminals to send live video to the command center. These videos can be combined with other surveillance videos acquired throughout the distributed camera network and projected onto a 3D "sand table" used to generate active incident scenarios, land forms, and resource distributions. Video streams can be tagged and redistributed across departments.

The Huawei Safe City project is a significant contribution to Karamay building a world-class public safety infrastructure. The project supports city-wide access to hundreds of camera feeds that enable thousands of police officers to effectively monitor the safety and security of a population of nearly 300,000. >>

The call center and dispatch systems are integrated with Geographic Information System (GIS) maps, so that call center operators are able to locate and notify nearby police officers by simply drawing a box on the map. Once point-to-point contact has been made, the dispatch operators are able to forward field videos, address information, and other detailed instructions to the officers' eLTE trunking terminals.

One function of the video cloud storage resource pool enables Karamay municipal police headquarters to share video files with branch offices. The result is the ability to facilitate cross-regional analysis and shared retrieval. The earlier problem of information silos is eliminated and incident investigations are able to be cleared accurately and efficiently.

Benefits for All
The Huawei Safe City project is a significant contribution to Karamay building a world-class public safety infrastructure. The project

supports city-wide access to hundreds of camera feeds that enable thousands of police officers to effectively monitor the safety and security of a population of nearly 300,000. In addition to maintaining a vigilant defense against counter-terrorism, it is estimated that the system is saving the cost of employing an additional 3,300 police officers. As a result of the system becoming operational, incident-handling times have been shortened from as much as 30 hours to as few as 30 minutes — improvement by a factor of 60 in emergency response resolution.

Using the massive amount of accumulated crime data over the past decades, the command platform has pre-integrated a variety of early warning scenarios. When exceptions are detected, the analytics platform automatically generates a prioritized alert. The affect is a broad reduction in the rates of crime committed and the broad maintenance of social stability. The political secretary of Karamay has said proudly and emphatically, "We have truly built a very safe city." ▲

Tips for Investing in an Enterprise Storage Portfolio

Zheng Yelai

| By *Zheng Yelai, President, IT Product Line, Huawei Technologies, Inc.*

Storage solution providers need to adjust R&D and product development plans based on changing industry trends, future data applications, and customer needs. >>

Companies investing in ICT do so with the idea of transforming their businesses and catapulting their corporations into positions of leadership within their industry. As the world gears up for full connectivity with "smart technologies" and the coming Internet of Things (IoT), protecting digital assets in modern enterprise storage platforms is understood to be a key factor in the process of ensuring the security and stability of mission-critical data.

Technical innovation is required to move the enterprise storage industry forward. Banks, for example, must reliably protect the personal information and financial assets of their customers. Due to increasing volumes of information — making it difficult to efficiently access and analyze disparate types of data — traditional storage solutions are bottlenecks for growth in today's digital economy.

Corporate R&D and fast-track product develop-ment are essential for meeting the growing demand for ICT-based storage in a market where legacy information islands and isolated data are routine obstacles. The best practice, look-ahead option is to design a "flexible" architecture that accounts for the ability to seamlessly retrofit one's current architecture for optimal data accessibility and the prevention of excessive redundancy.
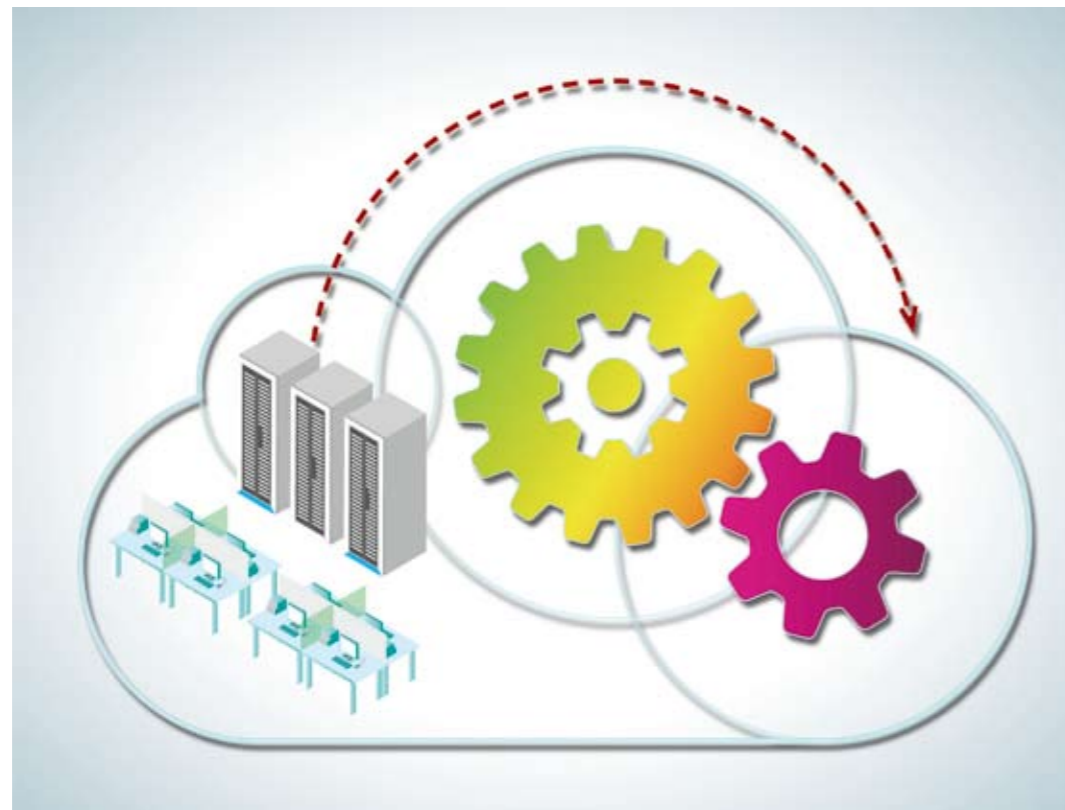
Storage solution providers need to adjust R&D and product development plans based on changing industry trends, future data applications, and customer needs. Common issues include the resolution data sharing issues, business continuity over the transition period between technical infrastructures, support for disaster recovery, and offering high-levels of security.

Huawei offers five investment tips for profiting from a converged storage system.

Tip 1: Unified Resources for Maximum Advantage

One way to tackle the data isolation problem is to establish a unified resource pool, which eliminates and encourages data flow as well as mobility between resources. A converged data platform solves the challenge with the benefits of 1) managing a range of storage mediums, 2) accommodating legacy systems, 3) enabling a variety of services, 4) provisions for comprehensive data protection, and 5) compatibility with third-party storage products.

Tip 2: Leveraging Convergence

The key to establishing a future-looking resource pool is to build an integrated software platform that includes all of the capabilities required by its users into a single solution.

One example is Huawei's next-generation OceanStor V3 series storage system, in which the OceanStor operating system has incorporated the protocols for Hard Disk Drive (HDD) and Solid-State Drive (SSD) primary storage with integrated backup; transparent data migration, support for heterogeneous devices, and policy-based control between entry-level, mid-range, and high-end storage devices.

Tip 3: Virtualizing SDN and the Cloud

Future cloud data centers, with IT services at their core, are expected to be the next major transformation of ICT systems. Helping to achieve the necessary alignment of integrated business needs are

Huawei is committed to a strong, long-term R&D program for enterprise storage. The goal is to provide our customers the best possible opportunities for sustained growth by investing in future-oriented IT ecosystems that include a converged, open-source data storage solution. >>

virtualization technologies such as Software-Defined Networking (SDN) and cloud management.

Tip 4: Accelerated Agility with SFV

Storage Function Virtualization (SFV) facilitates data storage, management, and services, with an emphasis on deployment flexibility. Basic data storage with advanced data management functions, such as retrieval and analysis, are integrated such that future enterprise storage platforms are less focused on physical devices. Similar to mobile applications that upload and download their data from cloud platforms, SFV enables a virtualized environment based on business needs for a flexible data storage system.

Through continuous R&D, Huawei will accelerate the implementation of SFV service architectures by overcoming technical difficulties and expanding its expertise in the area of converged storage.

Tip 5: Profit with an Open Ecosystem

As the Industry 4.0 era begins to unfold, the IT market remains influenced by open interface standards that enable an increasing number and variety of market opportunities. For instance, with enterprise storage platforms, it is essential that transparent data migration, similar to Huawei's roadmap for the OceanStor OS, be incorporated with innovative IoT-driven applications developed by partners and customers.

Huawei is committed to a strong, long-term R&D program for enterprise storage. We are currently collaborating with more than 500 partners across the globe, including Intel, SAP, Seagate, Microsoft, and Sobey. The goal is to provide our customers the best possible opportunities for sustained growth by investing in future-oriented IT ecosystems that include a converged, open-source data storage solution that is built for easy integration and the ability to generate revenue from collaborative and customer-oriented operations. ▲

Li Mingxiao

Customer-Centric Storage

| **By** *Li Mingxiao, Senior Marketing Manager, IT Storage Product Line, Huawei Technologies, Inc.*

The next revolution in storage is part cloud, part Big Data, part IoT. >>

Faced with new application requirements, customers are considering how to make their storage architectures more flexible, cost-effective, and easier to manage with faster response cycles to update services.

The focus on storage solutions is shifting, and plans are becoming more customized. It is safe to say that customers want more capacity, higher performance, and better scalability across the board. However, as the application environments of customers all vary greatly, attention must be given to the details of each IT agenda and storage build.

Now, halfway through the second decade of the 21st century, the "third platform" that includes mobile devices, social media, cloud computing, and Big Data, needs modern technical resources to serve mission-critical applications. The openness and flexibility of cloud computing requires storage solutions capable of providing on-demand scale-out, scale-up, and scale-down options to suit dynamic application needs. Achieving these storage performance options has required many engineering innovations in market where customers expect highly streamlined deployment and management processes.

Simplicity is at the heart of Huawei's customer-centric mindset, and our focus remains on fully tapping the trends in hardware and software systems convergence in the area of storage.

Driving Force behind Storage

Software-Defined Storage (SDS) is a component subsystem within the converged cloud architecture that has been designed to support the overall objective of dynamically changing service requirements based on real-time fluctuations in applications traffic. As is happening with networks and infrastructures, storage products are now also being engineered to separate the control and data planes such that customers are able to manage their technical resources at a group-policy level, independent of the low-level mechanics of each device.

Based on Flash memory arrays, the Huawei OceanStor DJ is a mass storage platform for the central management of data center resources, and is optimized for the transition of local storage systems to the cloud. OceanStor DJ offers new functionality to support the need for enterprises that are moving from simple data storage to higher levels of data management services.

Huawei's service-driven storage products use service-driven storage controllers to unify storage platforms and general-purpose servers into single resource pools able to implement intelligent management and scheduling. In addition, upper-layer applications can be assigned custom Service Level Agreement (SLA) resources, with the result that storage resources become automated and flexible.

Focus on Customer Needs

The core of the SDS storage process is that all functionality, including the management of storage resource pools, is implemented in software — and eventually, the complexity of managing heterogeneous storage will also be resolved in software.

SDS technologies are still in their earliest stages of commercial development, and each different vendor will surely approach their product offerings with a unique point of view. So, while the working principles of the SDS products between different vendors may vary greatly, the core focus of addressing customer needs by maximizing flexibility will remain constant.

In all cases, SDS is designed to unlock the full capabilities of mass storage hardware platforms, and virtualization techniques enable the deployment of unified resource management layers to organize scheduling and other high-level activities.

Tapping the Power of Convergence

The new norm in data centers and other IT infrastructures are converged resource pools able to schedule and allocate assets with maximum flexibility.

Huawei's service-driven storage products unify storage platforms and general-purpose servers into single resource pools able to implement intelligent management and scheduling. >>

The effect of this convergence is that SDS systems have become more powerful, efficient, and intelligent for mid-range and high-end markets when compared to the preceding generation of "unified" Storage Area Network (SAN) and Network-Attached Storage (NAS) solutions that nonetheless remained separated from the servers.

A key feature of modern convergent systems is the on-demand access to centrally controlled, multiple function resource pools that have blurred the lines between server, storage, and network components. During system set-up, the OceanStor OS operating system conducts a self-configuration analysis to determine the precise requirements for each particular cloud data center configuration.

With OceanStor OS at the core, Huawei's converged storage systems implement five convergence types — SAN and NAS; Solid-State Drive (SSD) and Hard Disk Drive (HDD); a single OS for entry-, mid-, and high-end systems; integrated backup; and heterogeneous device support — that, when combined, help users eliminate data islands.

Leveraging All-Flash Arrays

The emergence of all-Flash arrays onto the market gave rise to predictions that Flash would eventually become the only storage media used in data centers. And, as with every such projection, those who doubt aloud that this will ever be completely true. To date, considering whatever evolutions in storage are ahead of us, and whatever numbers of legacy, heterogeneous, HDD spinning platter platforms continue to be supported; there is no doubt that the population of all-Flash data center storage arrays is growing and poised to accelerate further.

Whatever may come in 2016, already on the market today are 4 TB enterprise-class SSD/Flash memories at storage costs far less than one dollar per gigabyte.

With continuous improvements in the reliability and availability of Flash memory — including the combined advantages of high performance, high density, low power consumption, and linear IOPS scaling — all-Flash arrays are moving from the "nice-to-have" column to the "must-have" column.

Clearly now quite mainstream, Flash memory has become the preferred form-factor for primary storage. Customers who require the highest performance in storage, such as the financial sector with high transaction volumes, are establishing a new baseline for the use of all-Flash arrays in enterprise data centers.

Huawei is actively collaborating in the further innovation of SSD controllers and Flash chips, which is leading us to increased accelerations in the installation of exabytes of on-line enterprise storage.

Whatever further revolutions will shake the storage field in years to come, we at Huawei are committed to maintaining a strong, customer-centric worldview — because it is only the storage products that fully address customer needs that will remain vital. ▲

Hu Yueqing

Shenzhen Omnimedia Media Cloud

| **By** *Hu Yueqing, Industry Marketing Execution Department, Huawei Technologies, Inc.*

Shenzhen Media Group met the challenge of implementing their media convergence initiatives by building a cloud computing platform for their radio and television business. >>

"Omnimedia" for the radio and television industry is the convergence of broadcast and Internet production workflows for news and information programming via an agile, digital platform. International giants — *The Guardian*, *The BBC*, *New York Times*, and *Wall Street Journal* among others — have all aggressively optimized their organizational structures and streamlined their production operations to meet the fast-moving demands of today's digital media market.

Shenzhen Media Group (SMGZ) — founded in 2004, based in Shenzhen, Guandong Province; owns twelve TV channels and four radio stations — which broadcast music, news, and talk shows by satellite, terrestrial, and cable transmission; some high-definition; mobile, pay, and shopping channels; music, traffic, and talk radio — an advertising sales company, and video, film, and sound studios. Total company assets are more than USD 805 million (CNY 5 billion). A long-standing business goal of the company is to extend their sphere of influence both domestically and internationally.

The functional analysis conducted by Huawei for SMGZ, and the broadcast domain in general, has made the conclusion that a flat, open, fully converged platform is the key to affecting the smooth transition from a traditional radio and television production operation to the widest possible access to an all-media — omnimedia — digital production and distribution service.

Truly a mix of the old and the new, under the control of the newest and most modern of operating systems, the omnimedia solution architecture falls squarely in the domain of Huawei's greatest strength: Information and Communications Technologies (ICT).

In this, as in other scenarios across industries in the ICT era, it is a cloud platform that unlocks the largest variety of co-production platforms and multi-channel options for radio and television program producers and editors.

Hybrid Cloud Infrastructure
How is it that cloud computing technologies are so effective when applied to media convergence initiatives? How do media organizations upgrade legacy workflow architectures to incorporate an open media cloud that meets current and anticipated demands?

A viable solution for radio, television, and internet publishing organizations is a distributed, hybrid private-public cloud that integrates widely dispersed network-connected resources. Media clouds are well-suited for traditional radio and television studio, machine room, and edit suite environments that benefit from adopting a physically decentralized, but logically centralized browser-based controller that addresses a Machine-to-Machine (M2M) array of otherwise discreet systems and components — including geographically distant components over long-distance carriers.

The accomplishment is that new services and new workflows can be configured quickly, electronically, with zero manual intervention. This is especially helpful during peak hours, where tightly scheduled resources are normal and routine.

The private cloud consists of a logic controller, local and central storage, and a core switch.

A hybrid cloud platform is created when a public cloud connects with an internal private cloud. The hybrid omnimedia platform employs a distributed architecture based on OpenStack with the ability to dynamically allocate resources for on-demand services. For example, the default allocation may be high-resolution resources for internal production and low-resolution resources for external services, such as streaming — and alternately, by schedule or breaking news event, a high-bandwidth external feed will be provisioned and left open until reassigned, or when internal storage services in the private cloud are running out of resources, traffic will be redirected to the public cloud.

"Single Cloud" Services
These needs cannot be met by universal switching and storage equipment or by common cloud computing architecture. Enterprises need a media cloud built on an open cloud platform that suits the characteristics of radio and television services.

Huawei has optimized its universal ICT platform to develop a distributed Infrastructure-as-a-Service (IaaS) media cloud platform for efficient video processing. The open IaaS platform features Graphics Processing Unit (GPU) virtualization, dynamic resource allocation and scheduling, efficient virtual desktop protocol support, and compatibility with industry-specific equipment and interfaces.

Using HDP+, an enhanced protocol that evolved from Huawei Desktop Protocol (HDP), the distributed IaaS platform provides smooth editing capabilities for HD video. The improved protocol support and optimized virtualization applies GPU pass-through and GPU hardware virtualization technologies to diverse HD Non-Linear Editing (NLE) scenarios. The solution enables smooth 6-track NLE of HD videos over four concurrent Virtual Machines (VMs) and implements synchronous audio and video as well. Unlike solutions using traditional siloed storage architecture — configured to process large numbers of high-bit-rate audio and video elements —the Huawei solution deploys an OceanStor 9000-based distributed storage pool. The flagship OceanStor 9000 product is built to use the storage resource pool, including ingested and uploaded raw footage, media content in production, and finished media assets for distribution or archival. The resource pool enables efficient resource sharing and dynamic resource allocation for multiple TV channels and media workflows. A traditional storage model requires multiple data transfers between disparate systems, wasting time and system resources. Huawei's unified storage resource pool prevents waste and can improve production efficiency by up to 60 percent.

Huawei FusionSphere, an open cloud platform with converged computing, storage, and network functionality, enables enterprises build Software-Defined Networking (SDN), service-aware networks. These networks are built to centrally manage IT resources and orchestrate fine-grain IT operations through automated virtualization. Under FusionSphere, private and public cloud IT resources can be integrated to function as if a single cloud is providing all services. The best operating efficiencies for capture and creation, editing, and distribution are achieved when additional public and/or internal data centers are internetworked and consolidated.

Significantly Increased Program Production Efficiency
Shenzhen Media Group's omnimedia news center officially launched on May 15, 2015. Huawei is the exclusive IT infrastructure solution provider for this project. In the newly converged facility, ICT resource pools have replaced traditional workstations; computing and storage are managed remotely and allocated dynamically; editors and journalists use virtual desktops to assemble and compose all manner of multimedia files, including audio clips, video feeds, transcriptions, and graphics. It is estimated that program production efficiency has improved significantly.

Built on a virtualized, all-IP infrastructure, delivered under exclusive contract by Huawei, the converged news center for Shenzhen Media Group is a first-of-its-kind production platform that sets a new standard for completing the integration of Internet publishing with radio and television organizations worldwide. ▲

Lv Chao

Peng Xiaopeng

Fast, Flexible "Ethernet Network Processor"

| By *Lv Chao, Director, Network Products Management Department, HiSilicon*
Peng Xiaopeng, Principal Technical Marketing Engineer, Network Products Management Department, HiSilicon

The architecture of Huawei's Ethernet Network Processor (ENP) provides the flexibility and performance for handling new services, end-to-end Quality of Service (QoS), and simplified management. The keys are programmable Network Processors (NPs) for specific Ethernet services.

Huawei's ENP switches are programmable and maintain high line rates. Designed for OpenFlow, ENP-based switches are integral to the future of Software-Defined Networking (SDN); so, in addition to handling today's services, will adapt to future needs with no change of hardware.

ASICs: High-Throughput, not Extensible
Application-Specific Integrated Circuits (ASICs) have long been the heart of high-performance packet switching. By processing network packets in silicon logic (hardware) rather than software, ASICs are highly reliable, secure, and cost-effective with low power consumption.

ASICs are responsible for the performance of today's gigabit per second speeds in addition to routing functions beyond basic Layer 2 switching. Large on-chip RAM supports Layer 3 switch functions for cloud services, video, Bring Your Own Device (BYOD), and Internet of Things (IoT) networks.

The downside is that ASICs, designed to process only pre-defined protocols, are inflexible. For example, if isolating an enterprise service within a discrete Virtual Private Network (VPN) using Multi-Protocol Label Switching (MPLS) — and the ASIC switch does not support MPLS — the enterprise would need new and different switches. In the same vein, an HD videoconferencing system may require an ASIC upgrade with a larger buffer capacity for handling bursty video streams. Even the smallest change in the forwarding process requires new silicon — which after design, fabrication, and integration, may take two years or more.

NPs Make Switches Programmable
NPs execute tasks ranging from packet processing to video segmentation performed by multiple Network Processing Unit (NPU) groups, where each NPU group has an independent instruction space.

NPs have greater flexibility than ASICs, though are often limited in performance. General-purpose NPs also tend to have high power consumption. The flexibility of NP architectures is limited by the instruction space of each NPU group. Overloading an NPU instruction space can limit the ability to deploy an additional service on the network. In general, the lack of automation — when instructions must be segmented by hand among the NPUs — results in buffer overloads among the NP groups.

For NPs to be broadly useful, they must be as fast and efficient as ASICs.

Fully Programmable ENP
Huawei set out to improve the flexibility and performance of NPs with the simple strategy of focusing on Ethernet services.

In the Huawei ENP architecture, the NPU groups differ from competing NPs in a significant way: the ENP groups can access the complete instruction space. Ergo, any NPU group can execute any instruction in the service process. This flexibility eliminates the need for programmers to segment services among the groups, meaning that Huawei's ENP silicon is more versatile than third-party NPs and has a simpler development process for creating new processes.

The resulting (ENP) chips are multi-threaded to reduce the influence of I/O latency to and from external memory, for instance on NPU group execution performance, and also benefit from a power-throttling method able to keep power consumption at the low levels associated with ASICs.

ENPs Boost Forwarding Performance
The ENP uses several strategies to speed up forwarding tasks, beginning with hardware-based pre-processing derived from Ethernet and IP packet forwarding methods. For example, the load on the NPU kernel can be reduced by pre-processing selected Layer 2, Layer 3, MPLS, and VPN services.

The ENP supports complex instruction sets for Ethernet and IP packet forwarding that enable long instructions to complete in fewer clock cycles than is possible with other NPs. Moreover, the use of branch prediction enables the ENP to execute multiple branches of code (such as if-else sequences) simultaneously and then keep only the result from the valid branch. The chip can therefore execute multiple instruction steps in a single clock period. This capability alone provides a significant performance advantage over other NPs.

Opening the Memory Access Bottleneck
Progressing from separate NP and ASIC processing and memory components, Huawei SmartMemory integrates a search engine, co-processor, and traffic manager into a single, on-silicon feature set.

The Huawei ENP SmartMemory processor makes memory access more efficient by eliminating memory access bottlenecks and the need for address latching and data synchronization co-ordination between separate components. The result is a great reduction in the processing overhead necessary to the ensure data consistency of multiple NPU sources interacting with shared memory.

In traditional IP/MAC address entry searches, devices get IP and MAC addresses using a two-step search operation that takes two memory I/Os. The first search returns an address entry index to the NPU groups, from which a second search is computed based on the new address. In contrast, ENP SmartMemory returns the final search result to the NPU groups and/or forwarding logic in one step.

Full Support for OpenFlow
OpenFlow, managed by the Open Networking Foundation (ONF), defines a standard interface between the control and forwarding layers of a network architecture, and enables switches from multiple vendors to be managed using a single, open protocol. The Huawei ENP engine supports OpenFlow traffic forwarding with as many as 16 million flow table entries.

The fully programmable ENP supports both OpenFlow and traditional forwarding. This hybrid forwarding mode ensures user service continuity for smoothly migrating networks from traditional traffic forwarding to OpenFlow forwarding, without having to buy new hardware.

Power Consumption Throttle
The integration of packet buffer and forwarding functions onto single ENP chips contributes to an overall reduction of power consumption. Additionally, an activated advanced power-saving throttle further reduces power consumption based on processing demand.

Specifically, a Huawei power monitor unit inserted between NPU groups and the data path tracks bits and packets per second of the ENP's internal traffic. As data rates decrease, the ENP disables both the power supply and clocks of some NPU groups to achieve maximum possible power reductions. As data rates increase, the NPU groups begin to work again, immediately.

Programmable Switches Enable Tailored Services
SDN promises to transform networks to support flexible service scheduling and management. To achieve this goal, Ethernet devices will need to provide excellent performance and high levels of flexibility. ASIC-based switches have the performance but no capacity to adapt to service changes, and conventional NPs do not meet the highest performance or flexibility requirements.

Tailored for Ethernet services and designed to support the flexibility necessary for SDN, fully programmable network switches, such as Huawei's ENP, are indispensable for supporting the full range of modern IT services. ▲

Immersive Reality: Opening New Kinds of Interactive Experiences

| **By** *James Begole, Ph.D., Director, Media Lab, Huawei Technologies, Inc.*

James "Bo" Begole
Dr. Bo Begole is VP and Global Head of Huawei's Media Technologies Lab creating technologies that enable business opportunities in new media experiences. He has published dozens of research papers and patents and has chaired leading international conferences in the field of human-computer interaction.

Virtual reality technologies are pushing new limits of computation, storage, and network infrastructures. **>>**

Immersion

If you've ever been engrossed in the setting of a novel, you know that visual detail is not required to suspend disbelief; it is the quality of the story itself that takes you away. Similarly for video games, use of the low fidelity blocks in *Minecraft* are as engrossing as the most advanced photo-realistically rendered games. Low-fidelity mobile games have cut deeply into the high-fidelity game console market because people can play anywhere, anytime and still feel immersed in the action of the game. Nevertheless, research has shown that it is also true that visual and audio detail does affect our sense of reality, making it easier to "suspend disbelief" and allow ourselves to become part of the story.

The killer application for immersive reality is probably gaming — where a single individual can wear a headset and become immersed in an artificial world. But "virtual" reality is not only about computer-generated artificial worlds. It is also about bringing remote places closer — places to which it is difficult to travel can be made real by delivering all of the light and sound that our eyes and ears can perceive using ultra-high resolution cameras, microphones, and low-latency networks. This kind of remote reality is a subset of virtual reality where the objects in the scene really do exist in the physical world, just not right in front of you.

The resolution of today's cameras seems astoundingly high — typical consumer cameras exceed 12 million pixels and some image sensors are able to capture more than 120 million pixels. At the same time, we see display resolutions increasing from High-Definition (HD, or 2 megapixels) to 4K (8 megapixels) and new screens are already available at 8K (32 megapixels) resolution. While these resolutions seem more than adequate for a "lean-back" experience of watching television or cinema content, is it enough for a visually immersive experience where the audience is interacting within the remote space by tracking objects and adjusting their focus in a scene at will?

A conventional movie or television presentation is a "lean-back" experience where the audience passively lets the director tell a story and the viewer follows wherever the camera takes them. In an immersive experience, however, each member of the audience can define their own interests that can change in an instant, depending on the activity. Let's be clear — we are recreating reality, not making a movie, not telling a story in which we draw the viewer's attention to a main character or object in a scene. In immersive reality, all of the visual and auditory data that a viewer may desire has to be ready at the turn of their head.

Immersive remote reality opens new kinds of interactive experiences where rich visual detail can make important differences. Imagine surgeons across the globe operating on patients remotely, skilled technicians manufacturing and repairing complex machinery, and students experiencing the most advanced hard-to-reach frontiers of science on our planet and eventually off-planet as well. People will soon be able to fly drones to tour exotic locations, pilot robots to meet with people, shop at the most exclusive boutiques in the world, witness point-of-view performances of world-class athletes on the field, and feel the full visceral experience of live music, on stage, right there with the band — all delivered in real time over low-latency networks.

Although the value of these experiences is clear, critical questions for developing the technology remain: What are the upper limits of detail to maximize the value of immersive experiences? Once

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answered, we can specify the upper limit of the amount of data that cameras, displays and networks will need to process.

Upper Limits of Human Visual Perception

It turns out that today's most advanced cameras and displays provide only a fraction of the detail surrounding us in the real world. Our eyes can detect dots in our view as fine-grained as 0.3 arc-minutes of a degree, meaning we can differentiate approximately 200 distinct dots per degree. Converting that to "pixels" on a screen depends on the size of the pixel and the distance between our eyes and the screen, but let's use 200 pixels per degree as a reasonable estimate. Our eyes can mechanically shift across 150 degrees horizontally and 90 degrees vertically which would require a region of 540 million pixels for full coverage.

Up to 540 million pixels for a static image; but the world does not sit still. For motion video, multiple static images are flashed in sequence, typically at a rate of 24 to 30 images per second for film and television. But the human eye does not operate like a camera. Our eyes actually receive light images constantly, not discretely, and while 30 frames per second is adequate for moderate-speed motion in movies and TV shows, the human eye can perceive much faster motion with some estimates as high as 200 frames per second. For sports, games, science, and other high-speed immersive experiences, rates of 60 or even 120 frames per second are needed to avoid "motion blur" and disorientation.

Other characteristics of the human eye exceed current display technologies. Our eyes can perceive a contrast ratio of nearly 1 million levels of brightness, requiring up to 8 bytes to fully encode the perceptible color gamut for each screen pixel.

Let's do a quick back-of-the envelope calculation of the upper limit now. 540 million pixels at 8 bytes per pixel at 120 frames per second would be 518 Gigabytes (GB) of data per second. No digital system or network in the foreseeable future can handle that kind of raw throughput. Fortunately, there is significant redundancy in visual data that allows — depending on the complexity of the images — for a great deal of compression. Even at a

Unlike the old days when new broadcast standards required a decade of more for widespread adoption, ultra-resolution systems are becoming adopted very quickly now that internet distribution allows the new to be downloaded on demand. >>

very high compression ratio of 300:1 that would require very powerful computers to encode and decode the compressed video, a 518 GB stream would still leave us with 1.7 GB of data per second.

1.7 GB per second sounds enormous, but still only scratches the surface of the amount of data surrounding us in the real world. If we add the ability for our heads to turn and bodies to rotate we would expand the visual field to 360 degrees horizontally and approximately 270 degrees vertically on which our eyes can focus at any instant in time: 3.8 Gigapixels at 120 frames per second requires a 3.7 Terabyte per second transport system! There are further attributes of human vision that can push the requirements even higher, as our eyes can adjust focal depth instantaneously. In the future, depth-capable displays will need to allow our eyes to dynamically bring objects in and out of focus. Today's commercial 3D displays cannot provide that, but light-field displays in research labs can, and this will require even more data per frame.

In addition to transporting enormous amounts of data, *full-field communication* requires that the data be compressed and transported in real-time. In 1968, Robert B. Miller, an early human factors scientist for IBM, established that the threshold under which humans perceive a response as "instantaneous" is less than 100 milliseconds. Additionally, some of the effects of motion sickness that people suffer in VR systems are caused by the delay between that person's motion and the system's response, requiring even shorter latencies to reduce such vertigo.

Making Remote Reality a Reality

What may sound like excessive amounts of data in today's world — where most home networks receive no more than 20 Mbit/s and businesses 100 Mbit/s — is on the order of one-percent of the necessary throughput for immersive reality. You may also question the demand for such ultra-fidelity in a marketplace where HD video has only recently supplanted Standard Definition (SD).

However, while HD may have felt like a future-proof format when first announced, it is now being quickly supplanted by 4K video cameras and displays. Forty-three inch 4K displays are now available for less than US$ 600, and many video streaming services offer 4K content. The resolution and physical size of displays continues to grow as just this year several camera and display manufacturers have announced 8K products and some streaming services have already begun to offer 8K content.

Unlike the old days when new broadcast standards required a decade of more for wide-spread adoption, ultra-resolution systems are becoming adopted very quickly now that internet distribution allows the new to be downloaded on demand.

MirrorSys: The Network is the Key

Huawei's first step into realizing the goals of *full-field communication* is a research prototype called MirrorSys that provides a fully life-size, real-time, realistic visual and auditory reproduction of a remote space. Introduced in Barcelona at *Mobile World Congress 2015*, and again in Hanover at *CeBIT 2015*, MirrorSys consisted of a 32 megapixel wall-sized display — a seamless array of sixteen HD projectors, 5 meters wide by 2.6 meters high — to match the resolution that human retinas can discern at a two-meter viewing distance. Following these early demonstrations, our lab has doubled the size and pixel count with a 10-meter wide by 2.6-meter high display. The audio system employs a 32-microphone array to capture the directionality of sounds from the source environment, and is accurately reproduced over a 22.2 channel speaker system. Because this system precisely localizes the point of origin for each sound, it is possible for the viewer to separate multiple conversations occurring simultaneously within different zones of the shared space. On the camera side, we have stitched together three 4K cameras running at 60 frames per second, and have compressed and transported the payload in less than 150 milli-
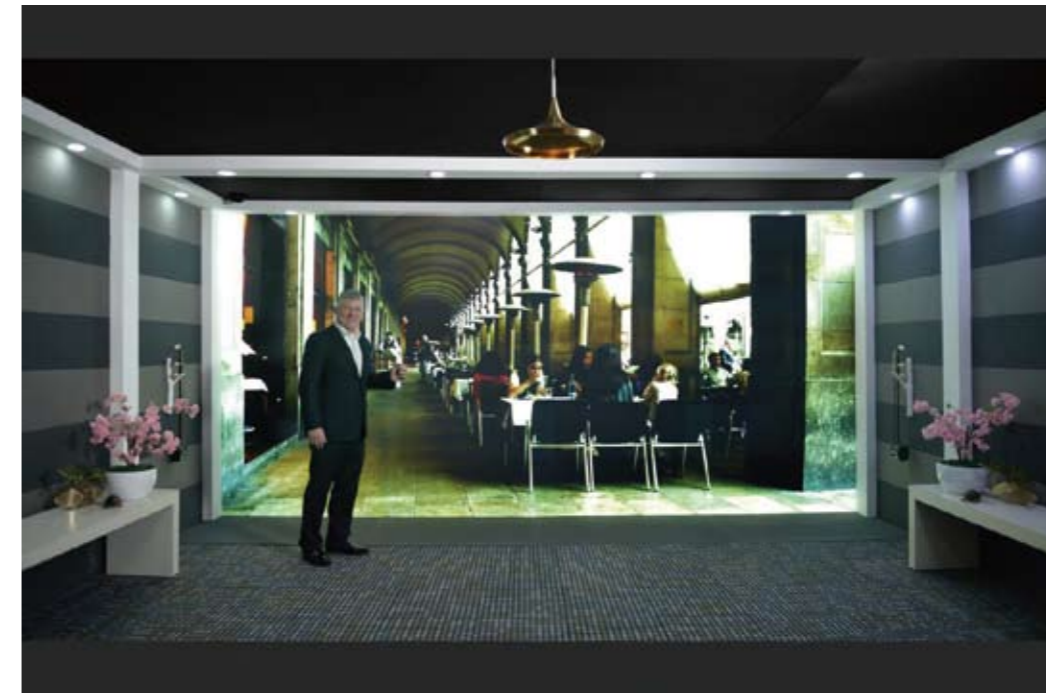
MirrorSys: Converging Video and the Environment

seconds across a dedicated network and we continue to drive for the lowest possible latencies.

Although the first MirrorSys prototype is capable of pushing today's network infrastructure to the limit, we know that we are really only scratching the surface. Whether the source imagery is from live cameras in the real world or computer generated, we understand that true immersion requires enormous amounts of data to match human perceptual sensitivities. Networks of the future will need to carry orders of magnitude more data and at latencies that are imperceptible to humans.

All of this makes clear that ultrafast networks are essential for the widespread adoption of fully immersive media. Other than playing games on dedicated local machines, most applications will require transport of some or all of the "reality" between servers and end-users — and even gaming is moving to cloud-based infrastructures that require shipping large data payloads around the world, as data center infrastructures are increasingly necessary to provide the necessary power for rendering realistic, artificial worlds.

Huawei R&D is developing technologies that can compress and transport all of the light and sound of a live remote or virtual environment in real-time for life-size, full-fidelity reproduction.

The future of MirrorSys, and *full-field communication* in general, is the ability for people to practically and routinely teleport to any location in the world — an accomplishment that will open a huge number of new business opportunities. Telemedicine will shift from talking heads over HD or 4K video circuits to the comprehensive visual detail necessary for accurate medical diagnosis and even remote surgery; remote technicians will operate and repair complex machinery; shoppers can examine real estate, precious gems, detailed manufacturing processes, electronic circuits, and other visually complex products with unprecedented precision. On the consumer side, fully immersive systems will let people become engaged with out of the ordinary activities that most of us will only ever dream of: climbing Mount Everest, visiting the Taj Mahal, piloting a Formula 1 car, standing on the field for World Cup football matches, skydiving, or diving the Great Coral Reef. Spectacular or heartening; the opportunity to visit with Mom back home or check-in with your children before bedtime when you are far away are irreplaceable moments in our lives. Virtual and augmented realities are opening countless new possibilities — but how many realities can a person actually live in? Just one, of course, but it's going to get a whole lot bigger. ▲

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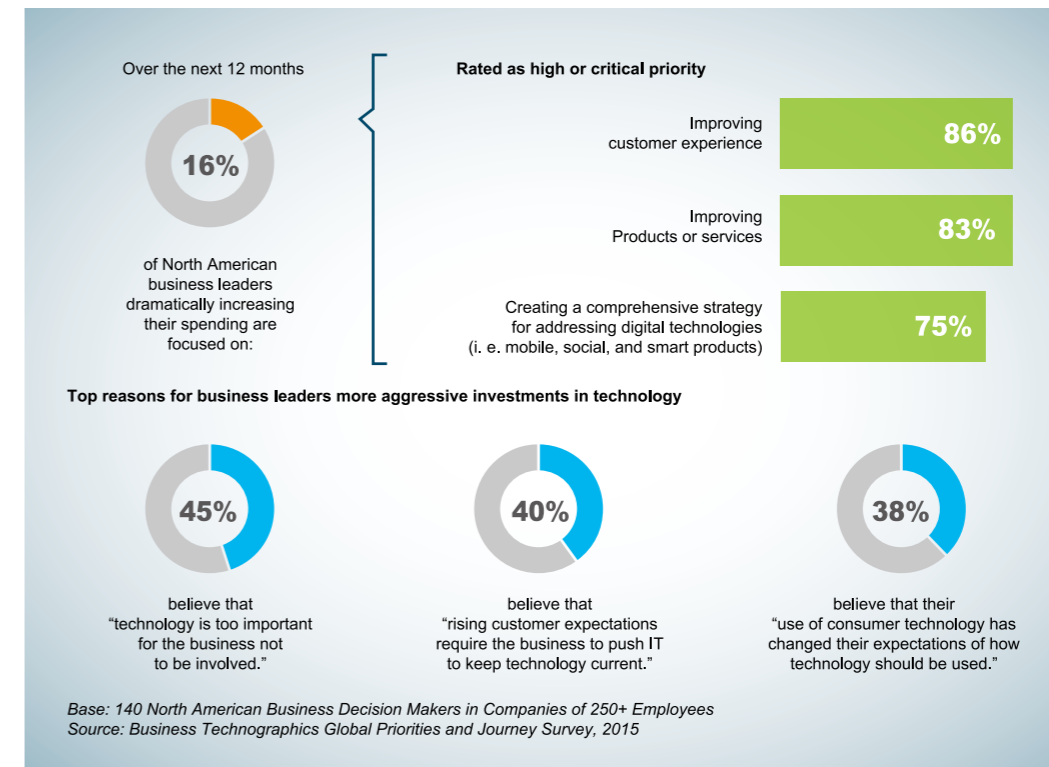
Tyler McDaniel

Tyler is responsible for product strategy, operations, and client servicing. He manages a team of data insights professionals who help Forrester clients understand technology adoption trends, buyer behavior, and customer journey information for purchases of technology products and services.

Business leaders are responding to your customers and will catalyze new value for your company. >>

Partner with Business Leaders to Lead the Business Technology Transformation

| By *Tyler McDaniel, Vice President, Business Technographics, Forrester Research*

For CIOs, finding a clear path forward in the Business Technology (BT) Agenda can seem daunting, as you work to balance critical operational requirements with new initiatives designed to help your organization win, serve, and retain customers. But there are trailblazers in your organization. Forrester continues to see spending on technology spread and move out of the CIO's silo and into the organization as a whole. In North America companies of more than 250 employees, 70% of technology spending is either business-led or heavily influenced by business. That part is not new, but it is increasing.

Over the next 12 months

16%

of North American business leaders dramatically increasing their spending are focused on:

Rated as high or critical priority

Improving customer experience — **86%**

Improving Products or services — **83%**

Creating a comprehensive strategy for addressing digital technologies (i. e. mobile, social, and smart products) — **75%**

Top reasons for business leaders more aggressive investments in technology

45% believe that "technology is too important for the business not to be involved."

40% believe that "rising customer expectations require the business to push IT to keep technology current."

38% believe that their "use of consumer technology has changed their expectations of how technology should be used."

Base: 140 North American Business Decision Makers in Companies of 250+ Employees
Source: Business Technographics Global Priorities and Journey Survey, 2015

Business leaders feel strongly that technology is linked to their success in winning, serving, and retaining customers through better experiences, products, and digital strategy. Partnering with these business leaders is essential to leading the transformation that is a cornerstone to the BT Agenda. >>

Specifically 50% of business managers, directors, and vice presidents are increasing their departmental budgets on technology products and services over the next 12 months. In fact, 16% of these business leaders are increasing their spending by more than 10%. This isn't shadow-IT in action; it's the new way of doing business. Within your own organization a minority, but important, population of business leaders are aggressively investing in technology products and services to achieve three essential business goals. Over the next 12 months, the 16% of North American business leaders dramatically increasing their spending are focused on:

• Improving customer experience — 86% of these leaders rate this as a High or Critical priority.

• Improving products or services — 83% of these leaders rate this as a High or Critical priority.

• Creating a comprehensive strategy for addressing digital technologies such as mobile, social, and smart products — 75% of these leaders rate this as a High or Critical priority.

Partnering with these business leaders is essential to leading the transformation that is a cornerstone to the BT Agenda. But you need to know their motivations so that you can work in collaboration with them, rather than see them as a threat that needs to be controlled. The following are the top reasons for their more aggressive investments in technology.

• 45% believe that "technology is too important for the business not to be involved."

• 40% believe that "rising customer expectations require the business to push IT to keep technology current."

• 38% believe that their "use of consumer technology has changed their expectations of how technology should be used."

These leaders feel strongly that technology is linked to their success in winning, serving, and retaining customers through better experiences, products, and digital strategy. They see themselves as the conduit of your customers that will push you to innovate with technology, and their technology acumen in their personal lives gives them the confidence to take charge and lead.

Don't ignore these leaders, and worst of all, don't work to contain them or shut them down. They are responding to your customers and will catalyze new value for your company. Sit down with these leaders armed with the insights about what motivates them and forge a partnership to promote the BT agenda. ▲

Yan Lida

Innovative ICT Enables Industries to 'Go Cloud'

| **By** *Yan Lida, President, Enterprise Business Group, Huawei Technologies, Inc.*

The cloud is changing everything about how we live and work in the world. >>

Looking at the past and future of technological development, we can see that we have arrived at the threshold of a digital economy that is driving economic transformation in all countries and causing great changes for individuals, businesses, and governments.

In *Unzipping the Digital World*, Keith Willetts, Founder and former Chairman and CEO of TD Forum, the global industry association for digital business, stated: "The digital world offers fantastic and unprecedented opportunities — but they won't fall into your lap. Most established players have been slow to grasp them and even slower at understanding the threats inaction will bring. We must bear in mind that, in the digital world, we cannot simply exploit new incremental business using traditional business models. Rather, we need to create new business models and services."

What are players in the new digital economies doing to seize this historic opportunity? Who are embracing the new technologies and business models with the most enthusiasm? Who are taking a "wait and see" position? Individuals, businesses, and governments have many choices to make.

During the transformation, the connectivity bridge between the real and digital economies will exert a far-reaching impact on human productivity and lifestyles. The effects of ubiquitous connectivity to the Internet are plain to see and, by 2025, Huawei projects that 100 billion devices will be connected to the Internet of Things (IoT). A fully connected world will be bursting with opportunities for new businesses and new wealth.

Cloud Computing is the Driving Force

Cloud computing has become the platform-of-choice for providing the wide range of applications which are necessary to manage our national economies, industrial infrastructure, and consumer services. We have all come to rely the cloud to live and work comfortably.

An important engine driving the transformation of traditional industries, cloud computing offers utility-scale computational power for generating the digital assets that are further leveraged by Big Data and IoT applications. The new standard for enterprise IT, cloud computing will increasingly dominate all aspects of manufacturing and production.

Building Cloud Ecosystems

In the digital economy, no single company can serve all customers in an industry. As an innovative ICT solutions provider with a global vision, Huawei is committed to creating new solutions with partners and customers to power the changes in industries.

Over the past four years, Huawei has massively expanded its public, private, and hybrid cloud computing business by working closely with our partners and customers on their ICT transformations. In particular, we have made great progress in the financial, urban government, media production, enterprise campus, and software development markets.

To date, Huawei has set up over 160 data centers and more than 700,000 virtual machines powered by cloud computing around the world. Leading companies are choosing Huawei as their best partner for innovation. In the financial sector, Huawei is working with Industrial and Commercial Bank of China (ICBC), China Merchants Bank (SMB), and Infocast. In the government market, Huawei customers include the Beijing, Nanjing, and Guangzhou municipal governments and the African Union. In the media industry, Huawei has relationships with China Central Television (CCTV), Shenzhen Media Group, and Phoenix TV. Huawei now works with over 500 partners in the cloud computing domain, including global leaders like SAP and Microsoft, as well as integration companies like iSoftStone and Sobey, that are focused on delivering specialized vertical solutions. In all cases, Huawei is collaborating with top companies throughout industry — and the most dense, heavily populated cities on Earth — to offer innovative cloud solutions to our customers.

• The financial industry is suffering from the double shock of competing Internet financial ser-

In the digital economy, no single company can serve all customers in an industry. As an innovative ICT solutions provider with a global vision, Huawei is committed to creating new solutions with partners and customers to power the changes in industries. >>

vices and the revolution of Big Data-rich cloud computing. To reclaim their leadership position, the financial industry must provide financial services that meet the demands of the Internet generation for promptness, reliability, and precision, and build IT systems able to dynamically allocate resources to match real-time changes in business volume. It is essential that the industry find effective ways to mine the massive volume of data it generates, as the leverage of these Big Data pools is at the heart of creating new value for marketing and services.

• New thinking is required to create service-oriented government resources able to support a culture of innovation at the local, regional, and national levels. How best for governments to harness new information technologies to achieve these deep levels of transformation and greater convenience for their citizens? What are the best practices for government agencies to collect and share information? How can government agencies simplify complicated bureaucracies while meeting all requirements for ensuring security and compliance? These are all common questions facing government officials and their IT service providers, today.

• For consumers, digital content over mobile broadband and social media are spreading like wildfire. Inside and outside of the media industry, the result is an unprecedented disruption in the viewing habits and levels of user input from the commercial audience — all of which is having a major impact on operations, production, and content processing for the service providers. The bar continues to rise for high-availability computing, mass storage, and broadband connectivity as users pursue ever-higher quality content, especially as it relates to 4K and 8K video.

Huawei invites its partners and customers to embrace our "Better Connected" world. As a leader in the business of enabling a more comprehensive information society, Huawei is committed to building ICT ecosystems that benefit of users at all levels. In all cases, our goal is to help you, our customers, to accelerate the transformation of your business vision into your full participation in the digital economy. ▲
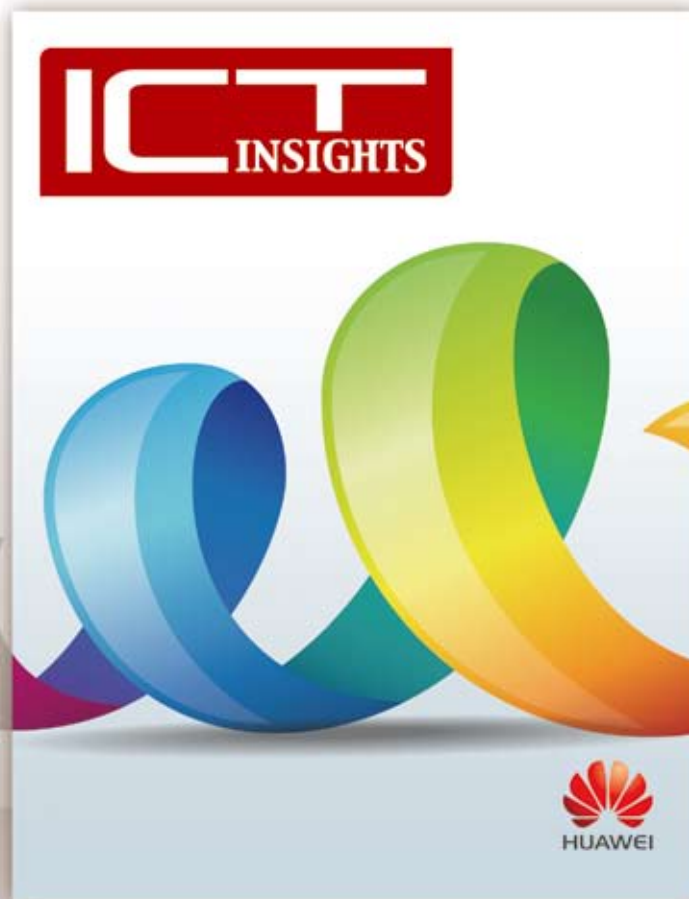
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