Leading New ICT Building a Better Connected World

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LEADING NEW ICT

Partnerships Lead to Secure SDN and NFV
Page 14 >>

Etisalat — 2020 Landscape (Part 2 of 2)
Page 22 >>

INDUSTRY CLOUD STIMULATES BUSINESS RE-INNOVATION

Rather than a simple combination of industries and the cloud, the 'industry cloud' is a convergence of businesses and technologies and a process of service-driven digital restructuring that promises to stimulate business re-innovation.

Page 6 ▶

Scan for mobile reading

Business Strategies for the Cloud Economy

Cultivating Leadership in a Post-Digital Era

GE Establishes Multilevel Strategy in China

HUAWEI

Comment

A Better View from the Cloud

| By *Ken Hu, Rotating CEO, Huawei Technologies Co., Ltd.*

An intelligent world is here, and it will bring about enormous changes in society. We simply have no way of knowing how deep and far-reaching these changes will be. However, we can be sure of one thing: Information and Communications Technology (ICT) will be its cornerstone.

The intelligent world has three defining characteristics: All things will have the ability to sense, all things will be connected, and all things will be intelligent. Our ability to achieve this depends on advanced ICT. Devices will be 'the feelers,' giving all things the ability to sense their environment. Networks will connect everything, and the cloud will be the source of intelligence behind all things. These three elements form a synergetic architecture of devices, information pipes, and the cloud, and they are the strategic focus of Huawei's investment.

In the future, all people and all things will have the ability to sense their environments, serving as entry points to the intelligent world. In the next five to ten years, beyond smartphones, we will see all kinds of smart devices that automatically adapt to different use scenarios. Optical fiber and wireless networks will provide us with ubiquitous, super-high bandwidth and low-latency connections — and interconnected computers distributed across the world will aggregate vast oceans of data, generating a 'digital brain' in the cloud. The intelligence it provides will evolve in real time, and it will never age.

The cloud's impact has gone beyond the confines of technology. It has affected business models and the way people think, and is responsible for a nonstop series of commercial transformations. The past 10 years have been the Cloud 1.0 era. Over this period, emerging Internet companies have leveraged cloud technology and cloud architecture to connect their customers better, and more effectively share resources between them. The last decade marked the beginning of business models based on agile innovation, better user experiences, and lower operating costs.

In the next 10 years, we will enter the era of Cloud 2.0, where enterprises will be the main players and we will see the rise of countless industry clouds. We estimate that, by the year 2025, the vast majority of enterprises will employ cloud technology and cloud models, and that 85 percent of enterprise applications will be deployed on the cloud. Companies will integrate their core businesses with the cloud and will always be on the lookout for new solutions that best suit their plans for growth.

At *Huawei Connect 2016*, we talked about the importance of generating practical value from the cloud, focusing on three steps that can help companies do just that.

To start, enterprises will need to change their mindset about the role that ICT is playing in their future: By recognizing ICT as a production system instead of a support system they can proactively use technology to jumpstart business innovation and redesign operations.

The second step is to rethink talent: The technical and human-factors skills for working with cloud-based ICT should become a basic requirement for all employees in a corporation — especially leadership teams.

And finally, companies need to think big and act small — find tactical points of entry, resolve practical problems, and create value. Gradual improvements will build lasting confidence in new technologies and the strategies that employ them.

Huawei's cloud strategy is to:

- Stay customer-centric
- Focus on ICT infrastructure
- Provide innovative cloud technology
- Become our customers' preferred partner
- Proactively contribute to cloud ecosystem development

Over the past 28 years, customer-centricity has been an integral part of Huawei's DNA — the most important guideline for everything we do. For Huawei's people, customer-centricity implies a down-to-earth approach, a willingness to learn from customers and to garner a true understanding of special needs in their industry. Customer-centricity means developing innovative cloud technologies and solutions that address those different needs — in effect, becoming 'Huawei On-demand.'

Our hybrid cloud solutions strongly emphasize openness, security, and enterprise-grade performance to provide integrated one-stop environments. These specifications are built on carefully honed insight into customer needs. When developing solutions, we recognize that customers need more than just a vendor — they need a partner that will work closely with their teams. Huawei is ready and willing to enter this type of strategic partnership.

Huawei will not release handfuls of clouds on our own. As an ecosystem enabler, we aim to help our customers develop a limitless array of clouds. We believe that the entire cloud ecosystem must be built around creating value for customers and that every member of the ecosystem needs to bring its own unique value to the table. As for Huawei, our role is to make good products and serve our customers well. A healthy, sustainable ecosystem needs the support of superior technology and products. Without them, success will be short-lived, and we will have carved a river with no water to fill it.

The road to digital transformation is bound to be long and hard, one full of challenges and opportunities. If we want to achieve our objectives, we need to get a better view from the cloud — see trends with greater acuity and build a grander vision. For any business, change is a process of rebirth; it brings hope. And through action, we can create the future. So, as we've always done, we will continue to put one foot in front of the other and, together with our customers, keep pushing forward. ▲

For Huawei's people, customer-centricity implies a down-to-earth approach, a willingness to learn from customers and to garner a true understanding of special needs in their industry. >>

Comment

News

Features

New ICT

Focus

Inside

Ecosystem

Success

Core Competency

Hands-On Technology

Speaker's Corner

Last Word

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Technology News

| Source: *PR Newswire*

Palo Alto Networks Raises Bar for Endpoint Security with Updates to Its Traps™ Advanced Endpoint Protection Offering

LAS VEGAS, Nevada, U.S.A., Aug. 3, 2016 — Palo Alto Networks® (NYSE: PANW), the next-generation security company, today announced new functionality, including significant machine learning capabilities for real-time unknown malware prevention, to its Traps™ advanced endpoint protection offering. These updates further strengthen the malware and exploit prevention capabilities of Traps and alleviate the need for legacy antivirus products to protect endpoints, such as laptops, servers, and VDI instances.

Many organizations deploy security products and software agents on their endpoint systems, including one or more traditional antivirus products. Still, cyber breaches continue to increase in frequency, variety, and sophistication. Traditional antivirus products struggle to keep pace and invariably fail to prevent these attacks on endpoints.

Huawei Launches Cloud Open Labs to Accelerate All-Cloud Evolution and Enable Digital Transformation

LANGFANG, China, Aug. 4, 2016 — Huawei today launched its Cloud Open Labs in front of 19 leading global operators, industry organizations, and partners, including the Linux Foundation, Open Platform for NFV (OPNFV), China Association of Communication Enterprises, Accenture, Red Hat, VMware, and Wind River.

As part of Huawei's commitment to the evolution of open source software, the Cloud Open Labs — with interconnected facilities across four labs — aim to enable operators' business success. These centers will provide the foundation for integrating and verifying solutions that enable the All-Cloud transformation.

World's Leading Custom Automated Manufacturing Equipment Suppliers Create Smart Automation Group

CHARLOTTE, NC, U.S.A., July 26, 2016 — Today, the world's leading suppliers of custom automated manufacturing equipment launched the Smart Automation Group, a ground-breaking collaborative partnership designed to disrupt the custom automation services industry.

This unique partnership, which includes Eclipse Automation, Insys Industriesysteme AG, Transmoduls Ltd, SMZ Wickel-und Montagetechnik AG, JULI Technology, and ITE Automation, are joining together to share best practices, industry IP, experience, and know-how to provide customers with automation solutions in a way unlike anything on the market today.

New Market Analysis Sees Huge Nano Coating Potential

HÜLZWEILER, Germany, July 26, 2016 — Leading analysts predict further considerable growth prospects in the nano technology sector for years to come. Experts calculated a worldwide market value of USD 3.8 billion up to the year 2020 for the antibacterial nano coatings segment alone. This is demonstrated in the business report of '*Global Industry Analysts.*'

For Nanopool, a manufacturer of high-performance coating systems, those figures affirm the strategic direction of their product development. In early 2006, the German patent and trademark office (DPMA) granted a patent for an antibacterial coating to Nanopool's Managing Director and inventor, Mr. Sascha Schwindt. This gives Nanopool the monopoly on the production and application of antimicrobial surface protection systems all over Europe until 2027. In particular, this includes vessels, harbor installation, oil platforms, and pipes, which are exposed to extreme stress in the sea water and need to be protected against fouling and other contamination.

Synopsys Delivers Industry's First Verification IP for Ethernet 200G

MOUNTAIN VIEW, Calif., U.S.A., July 27, 2016 — Synopsys, Inc. (NASDAQ: SNPS) today announced the availability of the industry's first Verification IP (VIP) and UVM source code test suite for Ethernet 200G. As the requirements for increased bandwidth to support video on demand, social networking, and cloud services grow, Synopsys VC VIP for Ethernet 200G enables System-on-Chip (SoC) teams to design next-generation networking products with better ease of use and higher verification productivity, resulting in accelerated verification closure.

u-blox Introduces Automotive-Grade, Qualified Positioning and Connectivity Modules

THALWIL, Switzerland, July 20, 2016 — u-blox (SIX:UBXN), a global leader in wireless and positioning modules and chips, today announced the expansion of its product offering with automotive qualified product variants added to their range of positioning and cellular wireless connectivity modules. The additions comprise the NEO-M8Q-01A and NEO-M8L-01A, and the SARA-G350-02A and LISA-U201-03A, respectively. Manufactured according to the ISO/TS 16949 automotive supply chain quality management standard, the modules are thoroughly tested with an extended qualification process to achieve the lowest level of failure rates. Leveraging the early production experience of tens of millions of professional-grade modules, u-blox automotive-grade modules consistently reach excellent quality levels. With long product lifecycle characteristics, u-blox manufacturing management includes industry recognized processes, such as automotive PCN, PPAP, and 8D failure reporting.

XCMG Brings XCMG-Cloud Online, First Industrial Cloud Platform Partnering with Alibaba

XUZHOU, China, July 21, 2016 — XCMG successfully launched the XCMG-Cloud on July 15, an unprecedented and highly inclusive industrial cloud platform based on XCMG's entire range of data and information systems in the Industry 4.0 revolution.

Eyeing the enormous potential in cloud computing, XCMG aims to revolutionize the traditional product and market model and transform itself into a platform-based and service-oriented company supported by Internet technologies. The configurable, multi-lingual, highly concurrent, and scalable XCMG-Cloud platform can host users around the world to promote open sharing.

The joint project with AliCloud, the cloud computer service provider of Alibaba Group Holding Limited, was announced on May 7 and entered the development phase on May 17. The team achieved success in just two months even though there were no prior mature examples to follow elsewhere in the world.

5G Deployments Forecasted to Begin in 2017

CAMPBELL, Calif., U.S.A., July 12, 2016 — Mobile Experts LLC released new research today, providing a specific forecast for pre-standard 5G deployment. The new forecast will be sent to all of the Mobile Experts 5G subscribers to highlight the very specific plans of U.S. operators as they ramp up deployment of wireless broadband services.

"The standards won't be finalized until 2020, but a few key operators have very specific plans during the next nine months," explained Joe Madden, Principal Analyst at Mobile Experts LLC. "American operators have spectrum already and are pushing to move very quickly to use '5G' for fixed broadband services. The size of these early deployments will be much larger than typical trials. We are expecting numbers that are more consistent with a wide commercial deployment."

New Altair CAT-1/CAT-M Chipset to Pave Way for Smooth Transition to Next Phase of IoT Connectivity

HOD HASHARON, Israel, July 6, 2016 — Altair Semiconductor, a leading provider of LTE chipsets, today announced that samples of its new dual-mode FourGee-1210 CAT-1/CAT-M chipset will be available later this year, enabling a smooth transition to the next standard of Cellular IoT networks.

While CAT-1 chipsets have been deployed globally for a wide range of IoT applications, carriers and vendors alike have been pursuing the emerging CAT-M (CAT-M1) and NB-IoT (CAT-NB1) standards that offer extended coverage and battery life capabilities, as the ultimate core technology for cellular IoT. However, there will be a lengthy transition period until sufficient coverage and standards maturity to enable complete conversion to CAT-M and NB-IoT exists. Until the ecosystem is ready to fully adopt these standards, a CAT-1 fallback will be required. This is what the FourGee-1210 provides. ▲

INDUSTRY CLOUD STIMULATES BUSINESS RE-INNOVATION

| By *Yan Lida, President, Huawei's Enterprise Business Group, Huawei Technologies, Co., Ltd.*

Yan Lida

Rather than a simple combination of industries and the cloud, the 'industry cloud' is a convergence of businesses and technologies and a process of service-driven digital restructuring that promises to stimulate business re-innovation. >>

User-centricity has become a new paradigm for the cloud. Indeed, in the technology-driven era of Cloud 1.0, we hear of many concepts — the public cloud, private cloud, and hybrid cloud — all of which are defined and understood from a technical perspective. In the era of Cloud 2.0, despite continuing to be a core technology that propels digital transformation, the cloud is expected to stimulate business re-innovation among various industries. The focus is no longer on cost reduction but rather on creating greater value. In a sense, the cloud is no longer a mere technology.

In this article, I want to present a different perspective; that is, the perspective of industry customers talking about what Huawei calls the 'industry cloud.'

Emerging Force

There is no doubt that the cloud era has arrived in a big way. Leading companies of various industries are actively exploring ways to use the latest digital technologies to inject new vitality into the processes, production methods, and even business models of traditional businesses. Against this backdrop, the cloud is poised to change the industry landscape.

- Smart Life, Better Life

If we consider that city management substantiates an industry, then the conventional concept cherished by this industry would be 'governance' in which governing bodies each set up their own chimney-like information systems that traditionally lack information sharing and struggle with service coordination.

By comparison, the Smart City is people-oriented with service as its core value. To meet the needs of citizens and businesses and provide them with better services, city administrators are using innovative cloud computing, Big Data, and other digital technologies to integrate the information systems of different departments.

- Real-time, Intelligent, and Personalized Service

Dramatic changes are taking place in the banking industry. For years, customer resources were under leveraged by traditional banking services that could not effectively share or utilize the data. Now, with the aid of the finance cloud and Big Data, banks have begun a process of user-centered transformation that emphasizes the people-oriented integration of systems and data to deliver an optimal real-time, on-demand customer experience. That is why in his book *Bank 3.0*, author Brett King predicted that, in the future, "banking is no longer a place you go, but something you do."

- Breaking the Limitations of Time and Space

Healthcare is an industry that relates to everybody's

Features

In the era of Cloud 2.0, the cloud is expected to stimulate business re-innovation among various industries. The focus is no longer on cost reduction but rather on creating greater value. In a sense, the cloud is no longer a mere technology. >>

Cloud platforms, network connections, and intelligent terminals are forming a new type of information infrastructure while data has become a fourth production factor following people, finance, and materials. >>

well-being. Nevertheless, the scattering of healthcare resources among hospitals and health institutions has long hindered quality healthcare service improvements.

Early on, the healthcare industry adopted the traditional disease-centered mode. Now, empowered by the healthcare cloud, the industry has constructed a better connected system that centers on people and connects all roles, medical processes, and health data involved in healthcare service. Such a connected system enables effective sharing of information and medical resources beyond the limitations of time and space.

● Reinvigorating Traditional Media

Content is the core for the media industry. Traditional forms of media are producer-centered in which producers are responsible for integrating content collected by media professionals.

The rapid penetration of intelligent terminals and the mobile Internet has changed the way people consume media. With an intelligent terminal, anybody can find and distribute content and become both a producer and a consumer of media. The media cloud provides a new ICT architecture that allows the media industry to integrate various content and resources, including broadcast, TV, newspaper, and social media, to build an open and convergent platform that is accessible anytime and anywhere.

● Engine Nearing a New Round of Revolution

It is no exaggeration to say that the industry cloud is becoming the engine for a new round of the industrial revolution. Cloud platforms, network connections, and intelligent terminals are forming a new type of information infrastructure while data has become a fourth production factor following people, finance, and materials.

Industry Cloud Essence

What, then, is the essence of the industry cloud, this so-called engine of the industrial future? Looking around the world, we find that one core function of all governments is to provide services for the public. In finance, risk control continues to be the lifeline of banks despite the emergence and penetration of Internet applications. In manufacturing, Mr. Fang Hongbo, Chairman and President of Midea Group, recently talked about the role of the Internet in Midea's business development strategy: "Midea is not an Internet company," he said. "However, we must digitalize our business by utilizing the power of the Internet, mobility, and business intelligence." I quite agree with Mr. Fang. Each industry is experiencing profound changes and whatever those changes are, they cannot change the essential characteristics that shape an industry.

The most pertinent analogy is perhaps one made by Huawei CEO Mr. Ren Zhengfei, who said in 2014: "The Internet hasn't changed the nature of things. A car is still a car, and bean curd is still bean curd."

Service-driven Digital Restructuring

New technologies, including cloud computing, are gradually becoming a part of the production systems of various industries. While Cloud 1.0 provided enterprises with general computing platforms, storage resources, and office suites, the Cloud 2.0 era will restructure enterprise IT systems, organizational structures, and business processes, subsequently rebuilding their business models.

Smart Cities, Smart Grids, omni-channel banking, and digital railways are typical examples of utilizing the industry cloud to transform traditional industries. Although the industry cloud presents a tempting vision, this vision will not become a reality overnight. Reaching a level of technological readiness to deploy solutions requires a process of systematic engineering that involves several factors that need to be carefully considered.

Key Factors in the Implementation of the Industry Cloud

● A Cloud-Pipe-Device Collaborated ICT Architecture

Future digitized enterprises are expected to construct new ICT infrastructures centering on the generation, transmission, and processing of data.

After years of development, technologies ranging from cloud computing and the Internet of Things (IoT) to smaller, less power-consuming terminal chips and communication modules have attained a high maturity level. Meanwhile, connection technologies are making continuous advances, from 4G to 4.5G and eventually to the future 5G. As a result, networks are growing to connect billions of terminals and effectively transmit mass data searched by terminals to cloud data centers in real time. Thanks to mass data computing, analytics, and mining capabilities offered by cloud computing and Big Data, the real value of information will be fully extracted and utilized.

Through the following cases, we will gain a clearer understanding of how technologies communicate with and depend upon one another to accomplish digital restructuring of industries through cloud-pipe-device collaboration.

· **Cloud Needs Networking.** In the Smart Transport industry, cloud- and Big Data-based applications provide cities with intelligent traffic management. By utilizing real-time traffic data, applications can perform predictive analysis of traffic conditions and generate early warnings on congestion that may occur, which allows timely and accurate travel-route planning.

Additionally, city administrative authorities are now stepping up the construction of 'devices' because they understand that without the massive amounts of traffic data collected by terminal devices, the intelligence of the cloud is of no significant value and cannot realize its full value.

· **Devices Cannot Stand Alone.** Similarly, several device-related issues that occur during digital transformation cannot be resolved using devices alone. At Australia's South East Water, a Victorian government-owned corporation, statistics show that Australia was losing about 30 billion liters of water a year due to pipe leakage. This problem had triggered huge losses among water companies. To address the issue, South East Water developed water pipe monitoring terminals that were installed in the water pipes and equipped with pressure, vibration, and other sensors to detect various pipe issues such as leakage in real time and collect and send the data to the cloud in real time. Based on the data, the cloud performs smart monitoring and management of water pipes. However, in actual deployment, South East Water discovered that the traditional people-to-people 3G technology used was not suitable for connecting things and did not meet the requirements of water pipes for communications services featuring wide coverage, low power consumption, broadband connections, and low expenditures.

Features

The Cloud 2.0 era will restructure enterprise IT systems, organizational structures, and business processes, subsequently rebuilding their business models. >>

Features

The digital transformation of an enterprise is a complicated makeover that involves a series of hardware and software systems. A good platform will help enterprises focus on business optimization and innovation. >>

South East Water collaborated with Huawei to introduce the Narrowband Internet of Things (NB-IoT) to the network side. Once fully deployed, this wireless network technology specially designed for IoT connections provides low-powered, low-cost networks with increased coverage that has the potential to unlock enormous value for water utilities and their customers.

- Monetizing with Industry-oriented Solutions

In the cloud era, data is the core asset of enterprises. For example, Huawei developed a credit investigation system for China Merchants Bank (CMB) based on a Big Data platform. With the Huawei solution, credit investigations were shortened from 15 days to minutes, greatly boosting the development of CMB's credit card business.

However, data itself does not speak. In our practice, we find that industries vary in terms of data generation scenarios, data formats, and data mining objectives. Therefore, the true value of data can be extracted only when considering the particular industry scenario involved. In such a case, accumulated experience in a particular industry becomes very important.

Huawei has long remained committed to joint innovations with customers and industrial application developers to help address differences between industries. The ICT solutions leader has collaborated with global customers to set up 36 joint innovation centers around the world. These customers are all leading enterprises within their respective industry, such as the Saudi Arabian Oil Company, Schindler Group, and KUKA Robotics Corporation.

- Smoothing Service Migration

Unlike the Internet industry, many traditional industries have a large number of legacy systems and huge amounts of data. For these industries, service migration is a challenging issue that must be properly dealt with during the implementation of the industry cloud.

Service migration involves different scenarios, including migration of traditional services to the cloud and migration of services between different cloud platforms. Implementing smooth service migration and ensuring a consistent, secure, and uninterrupted service experience is a challenge that may require a one-stop cloud service by a professional team.

In addition to smooth service migration, enterprises need to build up their digital operational capabilities. Only enterprises capable of independently operating and managing the cloud can maximize service innovation and operational security.

Challenges also mean opportunities. While enhancing their service migration and cloud operation capabilities, enterprises can also seize opportunities to build up new competitive advantages.

- Need for an Ecosystem Platform

The digital transformation of an enterprise is a complicated makeover that involves a series of hardware and software systems. No enterprise can accomplish this task alone. A good platform will help enterprises focus on business optimization and innovation without having to care about the complicated hardware and software systems at the bottom layer.

The mobile phone is a case in point. Before the emergence of smartphones, mobile phone manufacturers developed everything by themselves: software, hardware, and applications. This resulted in limited functions. The emergence of smartphones changed the rules of the game. Now, manufacturers only need to focus on the research and development of hardware and operating systems. They deliver smartphones as a basic platform on which applications developed by third parties can run. Consequently, millions of applications have emerged, greatly extending the functions of smartphones.

Similarly, enterprises need such a platform for their transformation. The platform must be open and elastic, and flexibly adapt to different applications deployed by enterprises. In addition, this platform must be highly secure and reliable. Only such a platform can muster the forces of application developers to form a vigorous ecosystem in which all parties work together to support the digital transformation of enterprises.

Becoming a Trusted Partner

We live in an era of business re-innovation — a time where everything revolves around service. While pursuing their own digital transformation, many leading enterprises are also thinking about how to apply their digitalization experience to serve more traditional production-oriented enterprises.

General Electric (GE) announced setting up a strategic partnership with Huawei in the industrial Internet field in August 2016 *(see GE interview, Page 32)*. As it plans to leverage its long-term accumulated advantages in the industry field and open up its capabilities to other companies, GE has set a very good example for trusted leadership.

"In the next 20 to 30 years, we will evolve into an intelligent society and experience a large and far-reaching technological revolution that is beyond our imagination," Huawei CEO Ren Zhengfei said. During the process of transformation toward the industry cloud, we must remain trustworthy and select a powerful platform that can allow us to confidently meet the challenges ahead.

Huawei is committed to building a platform that features cloud-pipe-device collaboration and constructing a sustainable ecosystem in which all players can thrive and prosper. In March 2016, Huawei's Enterprise Business Group (BG) released the new branding and marketing theme 'Leading New ICT' at CeBIT 2016 in Hannover, Germany. This theme expresses the company's strategic vision to pursue industry-oriented digital transformation.

As a concrete measure to carry forward the strategic vision of Leading New ICT, Huawei constructed and is now operating OpenLabs in Suzhou, China, Munich, Germany, Singapore, Mexico City, and Dubai, United Arab Emirates. Another three OpenLabs are being constructed and scheduled to open later this year in Moscow, Russia, Lagos, Nigeria, and Bangkok, Thailand. Each OpenLab is a center of innovation, solution development and verification, and user experience that is jointly operated by Huawei, customers, and partners. Moreover, we have established 36 joint innovation centers with industry leading customers around the world. These long-term and continuous investments are a concrete expression of Huawei's long-term commitment to its partners and customers. ▲

(Based on keynote speech delivered by Mr. Lida at Huawei Connect 2016, from August 31 to September 2 in Shanghai, China)

In March 2016, Huawei's Enterprise Business Group released the new branding and marketing theme 'Leading New ICT' at CeBIT 2016. This theme expresses the company's strategic vision to pursue industry-oriented digital transformation. >>

Liu Hao

All-Cloud technologies are maximizing the potential of Internet-based networks and transforming business models. >>

Accelerating Cloud Transformation for Carriers

| By *Liu Hao, Senior Marketing Manager, Cloud Core Network, Huawei Technologies, Co., Ltd.*

Today, we are in the midst of a transformation in which increasing dependence on the Internet is changing the way we study, work, and live. Internet-based user experiences now include Real-time, On-demand, All-online, Do-It-Yourself (DIY), and Social elements that Huawei calls ROADS. Technically, ROADS requires resource sharing, agile innovation, elastic extensibility, and easy maintenance. To implement the capabilities offered by the ROADS environment, carriers with traditional networks need to upgrade their network architecture, operating models, and service development methodologies.

Like the Internet Protocol (IP) technology of the last two decades, the recent boom in Software-Defined Networking (SDN), Network Functions Virtualization (NFV), and cloud computing promises to help carriers evolve their networks to become more open, interconnected, and innovative ecosystems.

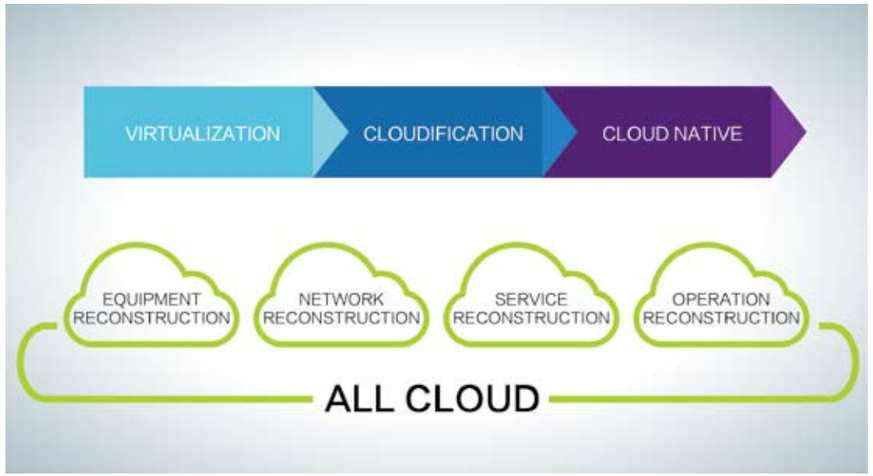
All-Cloud Architecture

During the all-IP era, Huawei was committed to the single strategy of supporting fast and efficient development for carrier networks. In this new era, Huawei is promoting an 'All-Cloud' telecommunication architecture that is agile, easily upgradable, efficient and, most importantly, enables the necessary digital transformation for business to keep pace with rapidly changing markets.

The advantage of the All-Cloud strategy is the ability to provide software-defined functions. Huawei's All-Cloud technology cloudifies the networks, services, and operations of basic network resources by providing pooled hardware resources to maximize resource sharing. The result is a fully distributed architecture that ensures high system scalability, elasticity, and reliability, as well as full automation of resource scheduling and troubleshooting.

Virtualization, Cloudification, and Cloud Native

All-Cloud implementations for carrier networks must go through three phases: virtualization, cloudification, and cloud native. Cloudification and cloud native implementations achieve full and complete network abstraction, while virtualization does not. The solutions most industry vendors provide today are designed for the virtualization phase, which only decouples software from hardware. The principles of the Huawei cloudification and cloud native designs anticipate the maximum degrees of abstraction for flexibility and reliability from the start.



Three Phases of All-Cloud Architecture

The NFV (virtualization) phase of development improves resource utilization by decoupling hardware and software, allowing the deployment of multiple Virtual Network Functions (VNFs) on unified hardware.

In the cloudification phase, the VNF architecture is optimized and reconstructed by using concepts that support a three-layer software architecture. The new architecture consists of distributed load balancing, distributed database, and stateless service processing units. It provides the ability to scale elastically within seconds without interruption to live sessions and introduces automatic service and resource orchestration to enhance the flexibility of the entire system. 99.999 percent carrier-class reliability for cloud networks is achieved using KPI-based health check, self-recovery, and disaster tolerance protocols that span multiple data centers.

When carrier networks enter the cloud-native phase, network slicing, agile infrastructure, microservices, containers, Platform-as-a-Service (PaaS), and other innovations are able to be incorporated into the construction of new ICT business models. The cloud-native environment is organized to assemble VNFs with flexibility, as needed, which allows for network services to be set up and released at any time, including the full automation of network Operations & Management (O&M) and service procedures. Carriers that complete the All-Cloud transformation become equipped to quickly meet specific network requirements for widely differentiated business demands.

Cloudification and cloud-native implementations achieve full and complete network abstraction, while virtualization does not. The principles of the Huawei cloudification and cloud native design anticipate the maximum degrees of abstraction for flexibility and reliability from the start. >>

Next-Generation Transformation

For carriers, a comprehensive All-Cloud transformation will catalyze fundamental changes to network architecture and organizational talent, as well as new business and operation models. Proactively exploring the technical and business impact of All-Cloud architectures with many of the world's largest and most innovative telecommunication carriers, Huawei is promoting a roadmap for success that can be referenced and replicated throughout the industry.

U.K.-based carrier Vodafone is preparing to deploy next-generation network technology as part of its 'Everything Moves on the Cloud' vision, which is designed to reduce costs, speed new services to market, and simplify operations. In July 2015, with Huawei's full support and assistance, Vodafone Italy announced the launch of the world's first cloud-based commercial Voice-over Long-Term Evolution (VoLTE) network.

Huawei has established NFV Open Labs in Xi'an, China, Silicon Valley, California, and Munich, Germany to complete integration verifications and prototype joint innovations with carriers, partners, and industry organizations with the goal of accelerating the industrialization of NFV.

As of Q2 2016, Huawei's strategic collaboration with leading telecom carriers has resulted in nearly 90 commercial cloud-based networks deployed or being deployed, including:

- World's first VoLTE cloud network for U.K.'s Vodafone
- Europe's first VoLTE cloud network for Belgium's Telenet
- Europe's first Evolved Packet Core (EPC) cloud network for Monaco Telecom
- World's first Diameter Routing Agent (DRA) cloud network for U.K.'s Hutchison Holdings
- Middle East's first commercial cloud network for Qatar's Ooredoo

Ooredoo and Huawei jointly won the '*Mobile Infrastructure Innovation Award*' at the *Global Telecoms Business (GTB) Innovation Awards 2016* in recognition of their achievement.

All-Cloud Development Trends

Industry leader AT&T launched its Domain 2.0 cloud project in 2013 to provide open cloud networks and reconstruct carrier services through a complete hardware-centric to software-centric transformation of the network infrastructure. AT&T plans to complete their network transformation before 2020. They expect that software will account for 75 percent of the cost to own and operate the network.

World-leading carriers Vodafone, Telefónica, Deutsche Telekom, China Mobile, China Unicom, China Telecom, Ooredoo, and Etisalat have released network transformation strategies and objectives for 2020. To support their efforts, Huawei will continue to advocate the benefits of All-Cloud products and solutions for carrier networks to better accelerate development and drive business success in the decades ahead. ▲

Liu Lizhu

The evolution of Software-Defined Networking and Network Functions Virtualization has triggered significant changes in security architectures. >>

Partnerships Lead to Secure SDN and NFV

| By *Liu Lizhu, Security Gateway General Manager, Enterprise Network Product Line, Huawei Technologies Co., Ltd.*

Challenges of SDN and NFV

Despite offering technologies that support fast reconfiguration and service requirement changes for cloud data centers, Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) possess a number of characteristics that expose network security to serious challenges. These concerns include complex service orchestration and resource scheduling as well as data forwarding between Virtual Machines (VMs) without involving dynamic changes to the network hardware equipment. This has rendered traditional architectures ineffective for meeting security requirements.

Against this backdrop are a number of proposed security solutions targeted to specific layers from traditional and emerging vendors, and Hypervisor or Virtual Machine Monitor (VMM) developers.

- Six Layers

Take the virtualization security solution as an example, which involves six layers. At Layer 1, a physical firewall serves the traditional role. Containers at Layer 2 isolate the applications from the host using IP packet filtering. At Layer 3, the in-kernel firewall performs state detection on traffic in and out of the virtual Network Interface Card (vNIC). Layer 4 houses common virtual firewalls that implement security between Virtual Local Area Networks (VLANs). Layer 5 consists of firewalls that implement similar functions to traditional firewalls between VMs. At Layer 6, VM-oriented firewalls provide security defense for endpoints and services.

- Traditional versus Virtualized

Traditional- and virtualization-based security solutions differ vastly, with traditional systems focusing more on host and network security (Layers 1 and 6), which are encapsulated by the entire virtualization set.

Traditional security vendors enjoy a competitive edge in the use of Layer 1 physical firewalls and provide the opportunity to establish VM-based filters at Layers 4 and 5 because physical firewalls and Intrusion Protection Systems (IPSs) can also be applied at these two layers.

In virtualized systems, the physical firewalls do not process east- and west-bound traffic between VMs. Traditional Layer 1 firewalls are irrelevant here because they cannot determine whether traffic between VMs is risky. Traditional vendors have repeatedly launched virtual firewalls for Layers 4 and 5; however, the virtual firewalls offered by traditional security vendors do not work independently at these two layers, as the diversion and scheduling of virtualized traffic at these layers remains in the domain of the Hypervisor and vSwitch vendors.

The results produced by SDN and NFV as they have evolved are often similar to the results seen using virtualization-based security solutions. Examples include cloud-based resource pools that meet the requirements of tenants running very different services; IPS and load-balancing services that adapt to user requirements; and SDN controllers that coordinate with security management stacks to produce optimal results.

- Who Owns This?

Both traditional vendors and Hypervisor vendors are currently seeking the most effective SDN and NFV security solutions available, so determining the roles of each at this stage is difficult.

The lack of standards or any clear evolution for SDN-enabled or NFV cloud automation adapted for security solutions results in a variety of complicated offerings. To a large extent, the situation reflects changes in business partnerships between players in the security industry chain.

Competition and Cooperation

Partnerships in the area of virtualization-based security are undergoing two types of changes. First, the division of labor in the industry chain has created the opportunity for more participants as some vendors focus on hardware firewalls and others on virtual firewalls or security at the container layer.

The second type of change involves players in the industry chain who are racing to make inroads into one another's markets. For example, while traditional security vendors are entering the cloud data center market through virtual firewalls, Hypervisor vendors are expanding their reach via security solutions at the kernel and vSwitch layers.

Gaining Momentum

To address the division of labor, security vendors and systems integrators are providing security solutions integrated with SDN and NFV that include chips, hardware platforms, hardware and software firewalls, and data security applications. Meanwhile, suppliers of every type are vying for a bigger slice of the market for virtual security platforms.

Because security assurance requires systematic engineering — more frequently than ever before — competing SDN and NFV security vendors are collaborating with one another as absolute security will never be achieved by single systems alone.

Security vendors have a deep understanding of network protocols for fast processing and superb analysis that Hypervisor vendors do not possess. Likewise, antivirus vendors are specialists in malicious file identification, and anti-leakage vendors have powerful algorithms for monitoring inbound and outbound data.

Hypervisor vendor capabilities now include CPU, memory, and Input/Output (I/O) isolation as well as the prioritization of cloud Operating System (OS) instructions and refined control of VM access to virtualized memory.

Building Security Together

The SDN and NFV security industry must build open, flexible, and elastic networks to establish healthy competition and beneficial partnerships. 'Open' means that security Hypervisor vendors, hardware manufacturers, chip vendors, and users must explore and collaborate on the multitude of requirements to connect SDN and NFV to the security and ICT infrastructures:

- Complete and reliable security solutions
- Consensus throughout the industry chain
- Ratified and de facto standards for software and hardware interfaces

To accomplish this level of cooperation, investors need to increase their financial commitments in the area of SDN and NFV alliances to support market-ready solutions for SDN controllers that are organized to manage customized scheduling and policy orchestration for the cloud OS.

Vendors must also build unified and integrated testing platforms to improve the readiness of SDN security solutions that support fast service innovation and flexible deployments.

The Cloud Security Alliance (CSA) is a non-profit organization with 86 local chapters worldwide. Members include the following large organizations:

- IT service providers Google and Microsoft
- Telecommunications operators AT&T and Orange
- Security vendors CA Technologies, McAfee, and Symantec
- Equipment vendors Huawei, Cisco, and Citrix

Among CSA's most important tasks is facilitating a collective discussion for the purpose of defining standards and regulations related to cloud, SDN, and NFV security. The goal is the creation of favorable conditions for the development of SDN and NFV security in the areas of architecture, management, compliance, application, and data schemas.

The benefit of encouraging competitors in the ICT and security industry chains to work together is the opportunity for each partner to draw on the strengths of others to improve the overall technical competence and efficiency of this critical sector. Through these relationships, vendors can provide users with high-quality solutions and join forces to build future-oriented and secure SDN and NFV services. ▲

Features

The Cloud Security Alliance is a non-profit organization with 86 local chapters worldwide. Among CSA's most important tasks is facilitating a collective discussion for the purpose of defining standards and regulations related to cloud, SDN, and NFV security. >>

Liu Yunjie

Director of the Science and Technology Committee of China Unicom, Dean of the School of Information and Communication Engineering, Beijing University of Posts and Telecommunications (BUPT), and Director of Jiangsu Future Networks Innovation Institute.

The architecture for Service Customized Networks is expected to provide differentiated service quality by using simple and open systems that are flexible, scalable, and secure. >>

Future Networks Trending toward Service Customization

| By *Liu Yunjie, Member of the Chinese Academy of Engineering and Director of Jiangsu Future Networks Innovation Institute*

After more than 40 years of development, Internet history can be divided into two stages. From 1969 to 1989, the technology featured studies on long-distance data transmission, and in the early 1990s, we saw the emergence of web technologies and electronic commerce. The Internet faces a new era of challenges that include the ability to adapt to new business requirements, accommodate huge and increasing volumes of traffic, and integrate seamlessly with the real economy.

Inflexible Network Architecture

According to industry statistics for 2016, Over-The-Top (OTT) services accounted for 71 percent of all Internet traffic. The positive effect for telecom operators is an overall increase in revenue. However, owing to the fact that the business model for carriers is based on access not volume, the rewards for their large investments in backbone networks are limited and subject to negative pressure. In addition to a hesitation to make long-term capital commitments, the consequences include risks to the industry value chain.

Can this problem be resolved simply by charging users for the amount of traffic they use? Obviously, charging all OTT services indiscriminately by traffic negatively impacts Internet industry innovations by hindering the healthy development and prosperity of the entire Internet ecosystem. According to a survey, 85 percent of users are willing to pay up to 25 percent more for a better customer experience, which means additional income for telecom operators who can meet the requirements of particular users for a higher Quality-of-Service (QoS) experience.

For example, in 2014, U.S. content provider Netflix agreed to pay U.S. broadband provider Comcast for faster speeds after Netflix customers complained about slow services that disrupted video quality. However, the current network architecture is not flexible enough to meet the QoS requirements of all users.

Rapid Internet Traffic Increases

An industry research report predicts that global IP traffic will increase from 59.9 Exabyte (EB) per month in 2015 to 168.4 EB per month by 2019, with video traffic accounting for about 80 percent of the total traffic. According to Vlinkage, as of October 2015, 232 Chinese TV dramas were played one billion or more times, revealing that a significant proportion of Internet traffic is redundant. If IP traffic continues to grow at the current rate, Internet traffic will soon become a thousand times greater than what we see today and telecom operators will be unable to meet the surging demand with a simple expansion of existing network capacity.

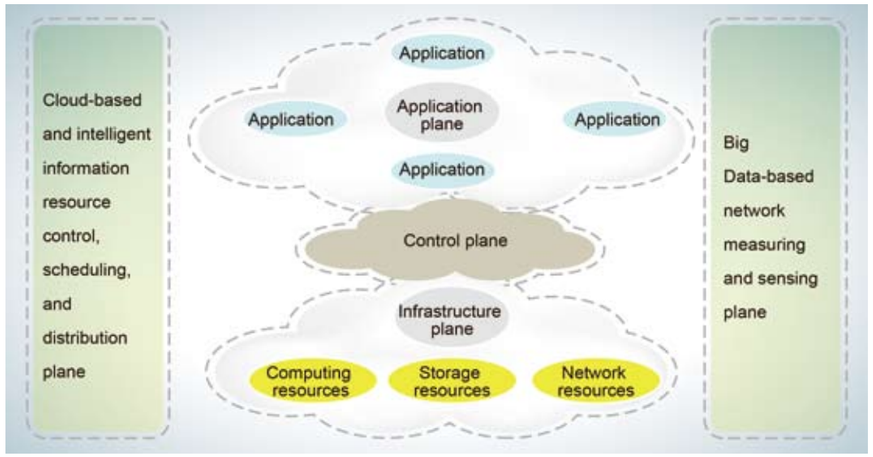


Figure 1: Service Customized Network Architecture

Unsupported Information

The next blue ocean strategy for the Internet is its integration with the real economy. In China, this is called 'Internet+' or 'Made in China 2025,' and in the U.S., Germany, and Japan, it's called 'Industrial Internet,' 'Industry 4.0,' and the 'Robot Strategy,' respectively.

Each of these strategies is designed to help businesses improve productivity. According to global consulting firm McKinsey & Company, a productivity overhaul in China could add USD 5.6 trillion to the economy by 2030. The reason is that China's labor productivity — a measure of output per hour worked — is only 15 to 30 percent of the average in Organization for Economic Cooperation and Development (OECD) countries.

The effort to improve productivity is a global issue, and many countries are pushing to start research on how best to participate in the Industrial Internet. In 2011, General Electric (GE) started R&D in Industrial Internet platforms and applications by establishing a global software center in San Ramon, California. The next year, GE released a report entitled *Industrial Internet: Pushing the Boundaries of Minds and Machines* that hailed the industrial Internet as the most significant player in the third wave of industrial innovation and revolution. GE announced in 2013 that it would invest USD 1.5 billion in their Industrial Internet program over the coming three years.

The global ICT industry is researching future-facing network infrastructure solutions such as Software-Defined Networking (SDN) and Content-Centric Networking (CCN) to address current and anticipated challenges.

The CENI pilot platform will be available for network architecture verification to promote further research and commercialization of future-oriented networks. >>

Service Customized Networks

To ensure sustainable, healthy development of the Internet and resolve major challenges, the industry must implement an architecture that provides differentiated user QoS. The Chinese Academy of Engineering is proposing a Service Customized Network (SCN) architecture to accomplish this goal. The SCN concept is derived primarily from the operating mode of the current transport system, which provides users with variables based on price and speed. Users select their desired means of transport according to need and ability to pay.

As shown in Figure 1, the SCN architecture comprises the following planes:

- Infrastructure, control, and application plane in the middle
- Cloud-based resource control, scheduling, and distribution plane on the left
- Big Data-based network sensor and measurement plane on the right

The infrastructure control plane consists of computing, storage, and network resources that allow flexible construction of virtual networks to provide differentiated services by user. The cloud-based resource controller intelligently schedules the distribution of content to resolve redundant transmission inefficiencies. The Big Data-based network sensor and measurement plane collects network status information to facilitate network scheduling, control, and security.

The SCN architecture has been acknowledged by Scott J. Shenker, Ph.D., a professor at the University of California, Berkeley and U.S. National Academy of Engineering in Washington D.C., and a leader in the movement toward SDN; Zhao Wei, Rector of the University of Macau in China and former Director of the Division of Computer and Network Systems at the U.S. National Science Foundation in Arlington, Virginia; and Peter Steenkiste, Ph.D., computer science professor at Carnegie Mellon University in Pittsburgh, Pennsylvania and head of the eXpressive Internet Architecture (XIA) project.

Future-oriented Pilot Network

Based on the SCN architecture, Jiangsu Future Networks Innovation Institute organized a program to construct a small-scale pilot network. To date, the network has been deployed in 26 Chinese cities, and over 80 user teams have applied for their own virtual networks to conduct private customized tests.

In August 2015, the China Environment for Network Innovations (CENI) project was initiated under the auspices of the National Development and Reform Commission. As the coordinator of the CENI project, Jiangsu Future Networks Innovation Institute has organized with over 60 universities and 40 research institutes and enterprises to pursue research, development, and construction. Once completed, the CENI pilot platform will be available for network architecture verification to promote further research and commercialization of future-oriented networks.▲

Part 1 of 2

Cultivating Leadership in a Post-Digital Era

A Forrester Consulting 'Thought Leadership' Article Commissioned by Huawei

Business leaders recognize that the only way to keep pace with change is to modify their organizational culture, break down silos, and encourage a customer-centric approach. >>

Success in commerce once meant building better products and services. In the post-digital age, however, products and services cannot succeed alone — you must design new digital experiences as part of your business model. And your business must be engineered to constantly innovate and evolve with emerging technologies. In other words, your existing business isn't designed for a post-digital world, and, without significant change, your survival is uncertain.

Emerging technologies continue to reshape market dynamics, and you must be agile to compete. New market differentiators set future digital competitors apart across all markets. Customer-obsessed firms exhibit greater business agility in customer service, use emerging technologies to create new sources of value for their customers, and reshape their operations around customer journeys.

To succeed, you must become customer-obsessed and fundamentally digital. Most businesses focus on bolting shiny new technologies, such as mobile Apps or impressive websites, onto their existing business or implementing technology solutions to gain operational insights and improve efficiency; however, this transformation — and creating the business agility needed to win, serve, and retain customers — requires changes in process and culture. You must rethink the way your products, services, and digital experiences combine to create value for your customers.

Because revenue growth now comes from the continuous application of technology innovation, investment criteria are shifting away from continuously minimizing technology expenditures. Instead, these investments are increasing, which raises a few pertinent questions: How should you develop an approach to business technology? How can you best unleash growth potential? What should be your key priorities?

Forrester Study: Trends, Growth Inhibitors, and Solutions

In June 2016, Huawei commissioned Forrester Consulting to evaluate some of the key global challenges, drivers, and trends facing businesses as they adapt to continuous change. To explore this trend, Forrester conducted a custom study to identify key business trends, growth inhibitors, and innovative solutions being adopted across industries. The study included in-depth surveys of 212 senior business and technology executives in the U.S., the U.K., Germany, Australia, India, Mexico, and South Africa. Participants are business and IT decision makers and leaders within their organizations.

This study yielded a number of key findings:

- **Every company will become a technology company.** In the near future, every company must learn to use technology to drive revenue. This will turn each one into a technology company, moving technology from the back office to the front and significantly increasing the risks and rewards associated with making the right investments.
- **Cloud services will become as common as electric lighting.** Without cloud connected technologies, little of today's agility and innovation would be possible. Cloud services will quickly become the default for technology teams globally, with increasing use of public cloud services in support of core business capabilities.
- **The level of change coming will dwarf everything that has come before.** Over the past 30 years, we've witnessed significant technology changes in business. But that's nothing compared to the changes coming in the next decade. As companies up and down the supply chain harness the power of Internet-connected technologies, the transformation will be seismic.
- **New technology architectures are needed to support the coming changes.** Old architectures are slow and difficult to change; therefore, companies must quickly learn to adapt their architecture. New architectures — designed for continuous change — will give leading companies a competitive edge. Digital sensors, Big Data analytics, Machine Learning (ML), Artificial Intelligence (AI), and emerging technologies, such as augmented reality, must be incorporated into the fabric of the business.
- **New business models will drive revenue and growth.** Technology-enabled services will replace the sale of widgets. We are rapidly moving into a business phase in which customers pay for outcomes enabled by the product, without the need to own it. Companies must learn to build new revenue models around the delivery of outcomes most valued by their customers. These new business models are enabled by such converged technologies as the cloud, the Internet of Things (IoT), mobile, AI, and Big Data analytics.
- **Companies must simplify most of their technology.** The days of customizing all of a company's technology are gone. Instead, executives must jointly agree to standardize and simplify the vast majority of an organization's technology to focus scarce resources on creating unique capabilities around the parts of the business that are truly differentiating for customers. To accelerate this innovation and change, and drive revenue, executives are turning to technology vendors.

Ready for a Post-Digital World?

Digital experiences are no longer an option; today, every business must integrate engaging digital experiences for customers (and employees) into the business model. Your customers want products and services faster, better, and cheaper, and with a better experience — and technology makes this possible. Thanks to powerful, consumer-friendly digital technologies, customers no longer have limited options and can now set expectations, define terms, dictate prices, and isolate bad supplier behaviors. You can no longer simply produce great products and services and expect to succeed. You must also collect and analyze data to design and deliver great digital experiences that create customer value.

Business leaders must create a compelling vision of a newly imagined digital business — one that the CEO and executive board can support. The old product-oriented business silos work well for efficiency, but they often work against customer centricity.

In the near future, every company must learn to use technology to drive revenue. This will turn each one into a technology company, moving technology from the back office to the front and significantly increasing the risks and rewards associated with making the right investments. >>

You must see the business from the outside in and transform into a company obsessed with pleasing the customer.

Even in transformational companies, however, legacy technology needs attention. The monolithic operational applications and hardware that run at the core are often slow and expensive to maintain and difficult to secure. These complex legacy systems can present a huge barrier to business agility. Technology simultaneously acts as a catalyst for change and hampers progress.

Becoming a Customer-Obsessed Technology Company

Because every customer now expects a digital experience as part of a supplier's value proposition, revenue growth is intrinsically bound to the ability to leverage technology. Transformational leaders use emerging digital technologies to create new sources of customer value.

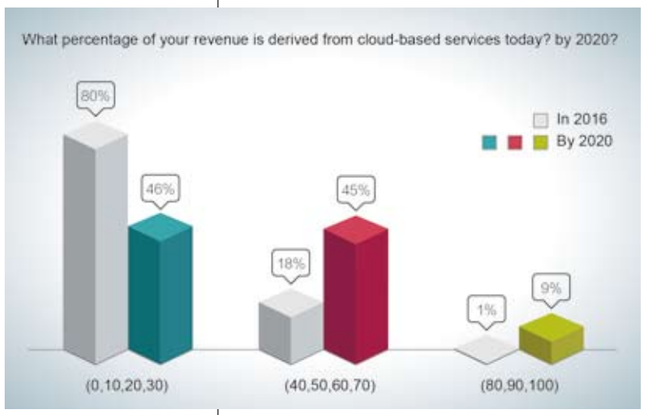
- **Transformation demands more than a 'bolt-on' Strategy.** Forty-eight percent of companies view digitalization as a means to extend the existing business model (adding a digital element like eCommerce or social media marketing) without fundamentally rethinking the way customers achieve the outcomes they value. This 'bolt-on' mentality works to a point, but transformational

The greatest challenge for companies today is that their business is not designed for the post-digital era. The customer's view is almost never reflected in the company structure. >>

companies go much further, re-imagining their business model from the outside in. Twenty-five percent of respondents to this survey already have a more transformational strategy in place.

· **Digital technologies improve customer experience and operational excellence.** Business leaders recognize the value of putting the customer at the center of their business strategy while also improving operational agility. Fifty-six percent of executives place improving operational excellence and agility with this customer-centricity as their top three priorities. And 53 percent place designing new digital customer experiences in their top-three business priorities.

· **Cloud services will form the backbone of tomorrow's digital business.** Cloud services are now commonly used across all industries, with 94 percent of companies reporting that they use cloud services to support core business applications. This dependence upon cloud infrastructure, applications, and advanced intelligent services will only increase. As companies gather increasing volumes of data, cloud services support AI and ML to analyze data at the edge of the network, creating near simultaneous machine-driven experiences for customers based entirely on their specific needs. Companies like the Switzerland-based Schindler Group already use cloud services to collect and analyze elevator data and provide predictive maintenance services for their customers. Soon, elevator companies may be paid based on how many people they can move per hour.



Tech Companies… They are not

The greatest challenge for companies today is that their business is not designed for the post-digital era. Product silos compete for scarce resources, especially from centralized technology and marketing teams. Technology is frequently tailored to the needs of functional units at the expense of simplicity. And the customer's view is almost never reflected in the company structure. These challenges also present an enormous opportunity for CIOs to help their companies change.

· **Organizational inertia across departments hinders transformation.** Twenty-seven percent of respondents pointed to organizational inertia across departments as a key barrier to digital transformation. Employees get used to doing things in a certain way. Indeed, many middle managers are rewarded for improving their specific, small part of the business, even if the overall impact is negative. For example, a requested change to a department's core technology system may improve productivity within the team; however, the true costs of such changes — increased complexity, high software upgrade costs, greater security vulnerabilities, and others — are rarely recognized. CIOs can help business units make better technology decisions for the entire enterprise and reduce technology debt over time.

· **Competing ownership challenges business executives.** As the appetite for digitalization innovation increases, multiple teams compete for leadership. Twenty-six percent of respondents see digitalization as an engine for growth and would like to own it. Without a unified approach, however, all teams vie for digital leadership and compete for resources. To solve this, some CEOs hire a Chief Digital Officer (CDO) with a mandate to champion digital transformation. But CDOs are not magicians; indeed, to succeed as a digital business, the entire organization must adopt a digital mindset and learn to collaborate in the service of customers. Digital transformation is like a team sport; by playing as a team, your organization is more likely to succeed. Every executive must share ownership of business outcomes, with CIOs taking a leading role in the integration of new technology assets across the enterprise.

· **A single view of customer data remains elusive.** Designing a company to deliver great products results in a product-oriented organizational mindset. But this inside-out position fails to consider the customer's viewpoint and frequently results in multiple customer datasets spread across the enterprise. Getting to that single customer view remains one of the most difficult technology challenges. Customer-obsessed companies must easily collect broad customer data and derive insights to create unique value for each customer. More than any other leader, CIOs are positioned to help meet this challenge.

Wave to the Future

The first wave of digital transformation was website development and eCommerce (1995 to 2010); the second wave was cloud computing, social media, and mobile Apps (2005 to 2015); and the third wave will be more holistic and comprehensive. All organizations will be forced to rethink the business around the possibilities of emerging technologies.

Once again, as in the early days of computing, technology separates the winners from the losers. Post-digital technology is no longer simply a tool for improving efficiency; it is the foundation for successful business strategy and future revenue growth.

Emergent Technologies will Drive Future Revenue Growth

In the post-digital era, new revenue models will be defined by the development of intricate ecosystems that combine the cloud, IoT, analytics, ML, AI, automation, smartphones, and augmented reality to deliver outcomes, create customer value, and drive revenue.

· **Cloud services enable rapid scaling for global audiences.** As the backbone of tomorrow's post-digital businesses, cloud-based technology services and infrastructure will dominate architectures. Emergent technologies will enable outcome-driven revenue models that can be scaled to a global customer base. Analysis of data across massively scaled cloud services will introduce a new range of intelligent services from public cloud providers. The percentage of respondents who expect over 80 percent of revenue to be generated from the cloud will grow from 1 percent in 2016 to 9 percent in 2020; those expecting 40 percent to 70 percent of revenues to be cloud-generated will grow from 18 percent in 2016 to 45 percent in 2020.

· **IoT and data meet intelligent machines.** Digital sensors enable companies to gather unprecedented volumes and varieties of data, and embedded wireless 4G (and soon 5G) technologies enable these sensors to be monitored in real time. Digitizing the physical world allows continual improvements, interactive experiences, seamless product integration, 'product-as-a-service' options, and faster design cycles. Big Data analytics and AI will enable new digital 'trusted machines' that create unique, high-value customer outcomes at the moment of need for each customer. Twenty-six percent of companies highlight 'digitally enabled products (the IoT/robotics/remote sensors/Internet connections)' as a top choice for new product design and development, and 23 percent of respondents believe that 'IoT-based customer experiences' will be one of the best ways to drive new digital revenues.

· **New custom manufacturing.** Automated manufacturing via sensors and data will make low-volume, highly customer-specific manufacturing viable. For instance, 3D printing will facilitate inexpensive, local manufacturing of custom parts on demand. Sensors on machines and parts will better connect the manufacturing landscape, enabling more personalized products in less time and for less money. As the manufacturing ecosystem evolves, a complex network of interconnected companies and machines will leverage cloud services and open Application Program Interfaces (APIs) to operate as a single, synchronized supplier, instantly adjusting to market changes and predicting shifts in demand patterns.

· **New digital experiences shatter human limitations to create a new digital reality.** As smartphone technology evolves faster than our capacity to adapt, intelligent agents (bots) will begin to take over and anticipate what we want to do next. Apps like the Waze navigation tool already do this by asking if we're heading home or to work, based on the time of day and current location. As the power in our pockets increases, augmented reality devices connected through smartphones will enhance our understanding of the physical world, blurring the line between digital and reality. The Pokémon Go game is a vivid demonstration of how powerful this technology can be in shaping human behavior. New revenue models are just a short step away. ▲

(In Part 2, we will discuss how to survive in the post-digital era.)

Hatem Bamatraf

Part 2 of 2

Etisalat — 2020 Landscape

| By *Hatem Bamatraf, Chief Technology Officer, Etisalat Group*

A summary roadmap for implementing a network transformation for speeding Time-To-Market based on Software-Defined Networking and Network Functions Virtualization. >>

Network Functions

As outlined in Part 1, Etisalat is striving to achieve a 60 percent virtualization of network functions by 2020. We summarized the market drivers for moving to virtualization, discussed the reasons behind the move towards Software-Defined Networking and Network Functions Virtualization deployment, and introduced the three key pillars that are the foundation of this future network architecture:

- Software-driven, data center-based platform
- Virtualized network functions and applications
- Agile and orchestrated operations

We also detailed the primary goals for Etisalat's future network: automated, scalable, and based on an open source platform.

In Part 2, we discuss the characteristics of network functions and operations and explore the business justifications that are helping us make the most informed decisions possible on utilizing our upgraded network.

● What's Virtualized?

We will look at activities capable of being virtualized using general-purpose, Commercial Off-The-Shelf (COTS) computers and then the functions that must remain fixed on dedicated hardware.

Hardware optimization technologies will remain effective for some time. In the domain of packet forwarding, Application-Specific Integrated Circuit (ASIC)-based performance improvements are well known and will improve further as semiconductor technology advances. Therefore, for the near term, COTS technology cannot and will not match ASIC-based performance.

Functions that require high packet performance in the data plane or low power consumption per bits transferred will continue to rely on ASIC-based components. Future innovations with COTS hardware are expected to bring improvements in the domains of Protocol Oblivious Forwarding (POF) and the new P4 language to further reduce performance gaps between custom ASICs and general-purpose machinery. The key question is whether a platform can provide an acceptable level of performance.

Conversely, network functions that require ease of integration or have high performance requirements and a shorter deployment cycle will be considered for virtual network functions operating on COTS hardware.

● Business Benefits

Etisalat conducted a comprehensive study of virtualization use-case benefits from three angles: 1) new revenue generation, 2) efficiency gains (architecture and operations), and 3) cost savings.

Virtual Customer Premises Equipment (vCPE) is the use case most targeted for revenue generation, whereas virtual Optical Line Termination (vOLT) and the virtual Broadband Network Gateway (vBNG) are the most targeted for improving efficiency.

- **Enterprise Focus:** SDN and software-defined data centers form a new enterprise service market known as the virtualized Data Center (vDC), which will allow enterprises to self-service their network and IT needs. The virtualized network and IT platform can be combined with enterprise data centers to build truly scalable data processing platforms with on-demand capabilities.

vCPE will allow Etisalat to transform its networking services to maximize efficiency, promote branding, reduce deployment costs, and increase telecom profits.

- **Cloud Data Center Foundation:** In addition to being a tier-one use case, the vDC has potential for generating revenue by allowing enterprises to form hybrid private clouds with distributed data centers.
- **SDN + CDN:** SDN can increase revenue and save costs. A Content Delivery Network (CDN) is essential for new services such as media, entertainment, and 4K/8K videos.
- **NFV:** NFV will allow operators to sustain growth by utilizing a virtualized platform without increasing operational costs.

Operations

'Content+ Services' is a future requirement that is already profoundly changing the landscape for operators focused on efficiency, cost reduction, and Time-To-Market (TTM). This requires a simplified Operational Support System (OSS) with an open and flexible architecture able to support the model of having standard APIs and using a Development Operations (DevOps) model. The new OSS must support the self-care needs of users and manage real-time interactions between users, partners, networks, OSS, and Business Support Systems (BSSs). To avoid new management silos, management should be centralized across physical, virtual, and cloud resources.

● SDN/NFV Impact on OSS

Virtualizing SDN/NFV network management brings new challenges to the OSS:

- Support of dynamic, policy-driven, near-real-time processes
- Mapping and tracking of virtual and physical resources
- Configuration, capacity on demand, and scaling
- Service chaining
- Root-cause and customer-impact analysis
- Tightly coupled assurance and fulfillment
- Intuitive and user-friendly service creation
- Integrated analytics based on real-time traffic measurements, customer behavior, and customer use
- Service exposure via open APIs and creation of an open business partner ecosystem
- Automated operations for both physical and virtual resources

Etisalat conducted a comprehensive study of virtualization use-case benefits from three angles: 1) new revenue generation, 2) efficiency gains (architecture and operations), and 3) cost savings. >>

Because physical-to-virtual mappings change in real time, troubleshooting can be a challenge. Real-time mapping tools ensure the visibility of account service chains and impact of full or partial movement of Virtual Network Functions (VNFs) across data centers. The OSS must detect malfunctioning orchestrators and automatically take corrective actions without impacting service delivery.

● OSS Architecture

To benefit from virtualized networks, operational flexibility, and service agility, the current OSS must change to support End-to-End (E2E) orchestration of multi-domain, multi-vendor networks and gain in capacity to manage both physical and virtualized networks.

This requires two layers: A BSS service layer and a service orchestration layer to communicate with multiple, domain-specific orchestrators.

The BSS and service orchestration layers must be separated to manage changes and network analytics support.

The following functional architecture for the new OSS is likely to emerge:

- The Information and Communications Technology Orchestrator (ICTO) and the Network Services

	Agile Access	Agile Metro	Cloud Edge	Cloud Core	Agile Core
Physical	Thin CPE CPE Data Plane	Optical Transponders Switches (Interfaces)	MPLS 'P' Devices Switches (Interfaces)	MPLS 'P' Devices Switches (Interfaces)	Optical Transponders MPLS 'P' Devices Switches (Interfaces)
Virtual	CPE Control Plane NAT Firewall DPI Encryption Compression/ Optimization	Control Plane Intelligent Protection	NVE vCPE vEPC (S/P GW) Control Plane vSTB, vParental Control vCDN, vCache vBRAS, vBNG vDPI, vFW, vNAT	vPE Control Plane vIMS vPCRF vEPC (Sig) vAAA vHLR/vHSS vDPI M2M/IoT/vVAS	Control Plane vRoute Reflectors vRoute Server vCGN

Physical and Virtual Functions Matrix for Telecom Domains

Etisalat plans to build and monetize a Big Data platform using our ecosystem to capture data related to interaction from customers, enterprises, OTT players, and service developers. >>

Orchestrator (NSO) will configure and deliver SDN functions and services.

- The SDN controller will interact directly with SDN-enabled devices.
- Enterprise Mobility Suites (EMSs) and VNF Managers (VNFM) will manage physical and virtualized resources.
- The cloud infrastructure will be managed by a cloud infrastructure manager, such as OpenStack.
- Content will be managed by a content management system, such as OpenCMS.

During the SDN 2.0 phase, the NSO will be needed for service agility, and a hierarchical orchestrator model will emerge soon after.

Eventually, the two OSS layers will merge to form a unified ICTO; however, they may co-exist for some time into the near future.

The hierarchical orchestration model is needed to differentiate the functions of each layer, while also hiding the complexities within each domain. NSO will be responsible for service definition and service policy management. It will, in turn, push policies to the SDN controller by communicating with NFV Management and Network Orchestrators (MANOs). MANOs will manage all aspects of the virtualized network.

This architecture supports a shared model between fulfillment and service assurance, and the model is designed to update in near-real time to capture network changes.

With the help of a policy engine, physical and virtualized infrastructure resources and the EMS analytics engine will use real-time feeds to extract intelligence and take corrective actions.

This architecture allows software to be designed in domain-specific components that support parallel work by multiple teams. Eventually, all OSS applications will be built with modular components that share common capabilities, which can be customized to allow rapid assembly of new behaviors. Each component is self-contained, including data, configurable metadata, workflow behaviors, and functionality.

● Evolving Role of the OSS

The orchestrator is critical to delivering the real OSS value and is supported by:

- E2E provisioning
- E2E resource management
- Service models driven by business metrics

Orchestration is the heart of automating Future Mode Operations (FMOs) and service lifecycle management. With DC processing capabilities available to all connected locations, the orchestration engine will coordinate SDN activation across the transport and data center network layers to form a virtualized, distributed network.

The orchestrator will deploy services by creating virtualized data centers, integrate with a design tool so appropriate services can be described and modeled inside the service catalog, and read the catalog and deploy the service.

Service inventory is shared between fulfillment and assurance functions, providing real-time mapping of VNFs to VMs. The event manager will correlate events to affected services. The host OSS system will see the entire network. The tenant OSS, interacting with the host OSS, will provide fulfillment and assurance visibility to partners for their portion of the physical and virtualized resources.

With the multitude of applications and domains, control cannot reside in a single monolithic software orchestrator or controller. Managing a specific complex domain requires expertly designed tiered architecture with distributed NSOs sharing a global view of the services and network provided by the ICTO. The NSO houses the network intelligence necessary for its contained domains.

● The Role of Analytics in Operations

Etisalat plans to build and monetize a Big Data platform using our ecosystem to capture data related to interaction from customers, enterprises, OTT players, and service developers. Operational logs generated by virtualized services and the OSSs managing the virtualized environment are key sources of analytics data.

The network must be instrumented in the data plane to track bulk and application traffic flow patterns and collect data. The analytics engine can be deployed at the edge for time-sensitive customer information and localized computation. This is useful for detecting multiple dropped calls for a mobile customer traveling to a different country, for example. The engine can also be deployed at a central place to mine customer sentiments about a CSP from data captured from multiple social sites.

Generating actionable events from collected data and acting automatically on those events to improve customer experience or SLA are essential.

By applying data extraction and mining techniques to collected data, real-time triggers are generated. The policy engine will then send directions back into the orchestration layers to self-regulate, self-optimize, and relay important network status changes.

A closed loop between assurance and orchestration, along with policy engine and analysis capabilities, will allow linking of operations with control, which will enable network self-healing.

● Service Management

The enhanced Telecom Operations Map (eTOM) is a business process and information framework that is maintained by the TM Forum to support service providers in the telecom and entertainment industries. The eTOM is structured around four major lifecycle processes that exist within each participating organization:

- Customer Relationship Management
- Service Management and Operations
- Resource Management and Operations
- Supplier/Partner Relationship Management

SDN/NFV-based OSS orchestration will allow entire service and resource lifecycles to be described as an information model able to render custom views of virtualized partner infrastructures to support their customers' networks.

FMO orchestration technology for software-defined services and service lifecycle management can be completely automated based on design-mode inputs.

● Reduced TTM

TTM is guided by two key OSS management processes in the new environment:

- Product lifecycles are guided by marketing: Global services are presented to each local market, with cost savings coming from the integration of social media and Big Data analytics.
- Service lifecycles are directed by engineering: Orchestration relies on the ICT architecture to reduce the time requirements for service creation, deployment, and problem resolution.

Total TTM reduction is projected to reach as high as 70 percent.

Conclusion

SDN/NFV-driven transformations based on the architectural guidelines detailed in Parts 1 and 2 of this summary have been devised to dramatically reduce the time required to launch and market new services.

In line with the Etisalat vision of the network and operations landscape for 2020, the following takeaways are valuable across the industry:

- Reducing TTM and deployment cycles is critical.
- Operators must develop a comprehensive understanding of SDN/NFV technology and its full impact on existing networks, operations, and organizations.
- Business cases with realistic targets need be arranged and followed to achieve a practical roadmap for SDN/NFV deployment.
- Current investments must be future-proof in alignment with a gradual plan for adopting an SDN/NFV infrastructure.
- Service orchestration is critical for operational agility and efficiency. Operators must insist on accelerating the development of open and unified standards for cloud Operating Systems (OSs).
- Open architectures are fundamental for the smooth deployment and ultimate success of SDN/NFV. To achieve this outcome, operators must begin to enforce certifications, lifecycle quality control, and rigorous integration testing.
- Vertical integration of cloud components is a risk factor for quick deployment. This can be avoided with pre-deployment integration tests and stringent verification processes.
- System integrators with IT and telco expertise are vital for the swift deployment of cloud-based networks.

To enable new communications, Content+, and IoT services, Etisalat will ensure rapid technology innovation by our team and our partners, as we plan to implement a modular, pragmatic, and simplified approach toward the goal of maximizing network virtualization. ▲

About Etisalat

Headquartered in Abu Dhabi, Etisalat provides innovative telecommunications solutions and services to 167 million subscribers in 18 countries across the Middle East, Asia, and Africa. This white paper is prepared in collaboration with Huawei. For more information, please write to egwhitepaper@etisalat.ae

Li Xianyin

Software-Defined Networking streamlines management and deployment and supports distributed edge computing for the Internet of Things. >>

A Creative Combination of SDN and the IoT

| By *Li Xianyin, General Manager, Enterprise Gateway Domain, Enterprise Network Product Line, Huawei Technologies Co., Ltd.*

Although the Internet of Things (IoT) is bringing enormous benefits with its wide range of terminal devices and intelligent applications, many obstacles have the potential to slow its progress. However, people swayed by IoT service values may have a tendency to ignore certain complexities. Traditional IoT architectures are not known for efficient management or real-time data processing due to massive numbers of terminals and gateways that populate the field. With this constraint, deploying IoT platforms at scale by industry users is difficult.

Huawei has developed the world's first Software-Defined Networking (SDN)-based agile IoT solution that combines SDN architecture with agile IoT gateways and the Agile Controller. Huawei's Agile IoT solution provides a better approach to management and deployment, driving industries toward the rapid implementation of the IoT's scaled deployments. To face the complexity and scale of IoT deployments, the following features were considered:

- **Management Support for Multiple Terminals:** Huawei predicts that two million sensors will be deployed every hour by 2025 — over 10 times the number deployed today. Intelligent terminals and gateways, including sensors, controllers, and numerous applications, require unified management components.
- **Effective Local Decision and Response:** Delays in decisions and responses are costly. Edge devices can process large amounts of data from on-site devices and determine which data should be uploaded to the cloud and which requires local processing. This method reduces the costs of data transmission and ensures real-time responses for critical services. However, on-site production environments are complex and volatile, and edge devices are numerous and scattered. Manual configuration and the loading of application and service components can no longer keep pace with quick decisions and responses during production.
- **Interworking of IoT Applications across Diverse Industries:** Siloed IoT solutions that do not interact with industry services are often impractical. Service requirements, interfaces, protocols, and standards vary from industry to industry; therefore, better interworking of IoT applications across industries is critical.

SDN eliminates the restrictions of traditional network architectures by isolating the control and data planes of network devices. SDN supports sets of functions that include centralized management and automatic network planning, deployment, operation, and maintenance. SDN has remodeled the IoT architecture to provide a flexible, scalable, dynamic, and open network for scaling IoT deployments.

Unifying Management, Control, and Expansion

The Agile Controller is the core component for the centralized control and management of entire networks. It is responsible for the unified management of IoT terminals, IoT gateways, computing resources, protocols, applications, and data. By combining Geographic Information System (GIS) visual management with dynamic network topology components, the Agile Controller supports plug-and-play for numerous devices and also provides End-to-End (E2E) normalized management and control.

The Agile Controller supports virtualization-based distributed deployment and dynamic reallocation of virtualized resources based on the required scale of different IoT applications. It manages and controls tens of millions of IoT terminals to satisfy the management and deployment requirements of numerous devices.

● Flexible Edge Decision Making and Responses

Agile IoT gateways capable of distributed edge computing play a critical role in processing IoT traffic, and edge devices may process up to 40 percent of IoT traffic by 2020. Using integrated computing and resource storage, edge devices are capable of providing rapid decisions when processing local traffic to ensure real-time handling of various production operations.

However, agile IoT gateways still require the support of the Agile Controller.

The adoption of an SDN architecture with an Agile Controller will not require on-site manual configuration. This guarantees few difficulties when deploying computing, storage, and application resources on edge devices. Because SDN supports a programmable IoT network architecture, service components are predefined with different strategies and control functions for service flow control. For example, SDN triggers dynamic and on-demand component loading based on the on-site service flows, sector by sector and region by region. This process ensures automated planning and deployment of application resources for multiple edge devices to deliver immediate responses to complex production situations.

● Open Interworking with Applications in Multiple Industries

Open interfaces distinguish SDN from traditional IoT architectures. Agile Controllers provide multiple programming interfaces (APIs and eSDKs) for upper-layer network applications that allow IoT applications in various industries to invoke the capabilities of underlying network devices and conduct data subscription and allocation. These interfaces have laid the foundation for scaled IoT deployments in different industries that enable collaboration between partners to further develop specific applications.

IoT Teams Up with SDN

IoT environments are open ecosystems that require close cooperation among different fields. Empowered by SDN, agile IoT platforms are being deployed in 'smart' buildings, 'smart' grids, connected city lighting, and onboard management.

For example, the connected city lighting solution centralizes management and control for large numbers of road lamps, and adds SDN-based multi-class control. SDN control components include time- and location-based lighting fixtures with different policies hosted by the Agile Controller. The controller collaborates with a built-in GIS management platform to dynamically load these components to roadside edge devices by districts. Should a fault occur on the control network, the SDN system will automatically detect the problem and rapidly switch to a predefined local control mode. The local override of central control saves electric power consumption by up to 80 percent by deactivating road lamps during the day. The SDN open architecture supports seamless access to smart devices like traffic and environment monitoring equipment and charging poles.

SDN provides services such as vehicle management and data statistics over standard interfaces. These interfaces enable SDN to interconnect with third-party service platforms — that through the Agile Controller — achieve the unified management of thousands of vehicles, including city and school buses, and commercial trucks. These connected devices are equipped with many differentiated onboard services, including onboard surveillance, Wi-Fi, and security.

Applications vary among manufacturing energy, and onboard services. IoT service providers must collaborate with partners in various fields to explore the true service requirements for each market, adopt SDN architectures to rebuild service chains, and plan specific services and application flows based on service changes at the necessary deployment scale for each industry. ▲

Empowered by SDN, agile IoT platforms are being deployed in Smart buildings, Smart grids, connected city lighting, and on-board management. >>

Jarrett Potts

Buying more disks and servers, and adding controllers and virtual machines could no longer keep up with the scale required by some environments. Now, the storage industry is turning its attention to software for a solution. >>

Redefining Storage with a Software-Defined Solution

| By *Jarrett Potts, Worldwide Director of Storage Marketing, Enterprise Business Group, Huawei Technologies Co., Ltd.*

Software-Defined Storage (SDS) has had a significant impact in the data center and cloud realms. Already, software-defined products are unifying data centers by enabling better control and more scalable environments. But the question remains: What can it really do for storage?

SDS is a component subsystem within a converged cloud architecture designed to support dynamically changing storage requirements based on real-time fluctuations in application traffic. As with networks and infrastructures, storage products are being engineered to separate the control and data planes, enabling technical resource management at a group-policy level — independent of the low-level mechanics of each device.

The core theory of the SDS process is that all storage services, including resource pool management, are implemented via autonomous SDS controller software that is decoupled from standard server-based storage hardware. While the working principles of SDS products between different vendors may vary, the focus on maximizing flexibility to address customer concerns is a common goal. SDS is designed to unlock the full capabilities of mass storage hardware platforms in all cases, and virtualization techniques enable the deployment of unified resource management layers to organize scheduling and other high-level activities.

Historical Perspective

At one time, costly segregation of physical infrastructure components by vendor was the norm. Data could not be shared or moved from one vendor's storage device to another without significant labor and, usually, paying for a third-party product or driver.

'Hardware creep' set in as more servers, racks, and other equipment were acquired to grow. Then, storage virtualization came along with the creation of a hardware abstraction layer that lays across multiple-vendor storage devices. This meant all disks from the different vendors could function as a single disk pool. Storage virtualization helped protect the existing infrastructure while allowing for future expansion.

But storage needs kept growing, and, with the wider acceptance of the cloud model, storage virtualization was failing to be enough. Big Data, the IoT, and all the other trends compounded the growth of data, necessitating the introduction of a logical layer to optimize operations of the storage, network, and server infrastructures.

A Star is Born

Thus, the software-defined age was born. The idea was simple: Create a vendor agnostic platform from which to work and a virtual layer that helps direct the 1s and 0s more efficiently. This software-defined environment could include Software-Defined Networking (SDN), SDS, VMware, KVM, and other servers. Using these software technologies together produces a new type of environment: hyper-converged. Because functionality is free from the physical infrastructure, automation and management become more flexible.

SDS Benefits

· **Logical Storage Abstraction** places a virtual layer between data requests and the physical storage component. Allowing manipulation of where and how the data is distributed, the storage abstraction layer enables a heterogeneous storage infrastructure while still controlling the entire process from a virtual instance. Users can present storage repositories to the SDS layer to allow that instance to control data flow.

· **Intelligent Storage Optimization** permits the efficiencies of existing storage not yet utilized. Capacity pools are created and data can then be delivered to that pool using the correct storage type while still utilizing built-in disk array features like de-duplication, compression, and thin provisioning. So, for a tier-one application like SAP HANA (an in-memory, column-oriented, relational database management system), a storage pool of Solid-State Drive (SSD) disks can use only the disks suited for that application. The real power is the flexibility of choosing what is used for each application or environment. For SAP HANA, disks from three different storage arrays and three different vendors can be used because the entire array is assigned to the software-defined layer — or just a shelf or two.

· **Creating a More Powerful Storage Platform**, in this case, a hybrid storage model, provides a virtual control layer for the physical disk that allows the use of the physical and virtual storage features. Users can create a logical control layer that helps manage all the physical storage, regardless of the vendor, in the data center. The storage platform prevents vendor lock–in and permits migration of data or applications from different storage arrays.

· **Regaining Control of the Storage Infrastructure** is a fundamental issue that must be addressed across the entire infrastructure. How many disks, shelves, arrays, and controllers must be bought, and which vendor is the right fit?

Personnel must know and fully understand the I/O–intensive applications and where each data stream needs to be stored. Organizations must change how they think of storage in order to create tiers of logical disks that are independent of the physical systems.

By creating powerful virtual SDS applications that control their data infrastructures, organizations will see, control, manage, configure, and migrate data from one disk, or sets of disks, to one or more others. Disks will no longer sit in reserve storage arrays.

· **Expanding Cloud Storage** is simplified due to the ability of SDS to dynamically expand physical data centers into the cloud. Creating storage links from on-site IT systems to public cloud vendors establishes distributed data centers for replication, Disaster Recovery (DR), and load balancing. The long-term advantage is that data storage will happen at the virtual layer between heterogeneous storage components on site and in the cloud.

· **Hyper-Convergence** is the result of combining SDS with other software-defined technologies. Systems with virtual servers, using virtual networks with correct memory, user, and zoning allocations, and virtual data pools can be matched exactly to the needs of each application — in minutes instead of weeks.

As a way to avoid buying more disks or being constrained by a fixed platform storage infrastructure, SDS technologies abstract entire storage pools for the purpose of 100 percent utilization. >>

Summary

Industry is beginning to leverage the power of storage, regardless of vendor, location, or technology. Organizations looking at present-day resources will pool and distribute them on a global scale. With the vast quantities of data being generated each year, a better way to control the flow of the information was required.

As a way to avoid buying more disks or being constrained by a fixed platform storage infrastructure, SDS technologies abstract entire storage pools for the purpose of 100 percent utilization. Like every other physical component in the data center infrastructure, virtual layers can truly help optimize resource consumption. Server virtualization has helped mitigate server sprawl, application virtualization has helped create new delivery methodologies, and now, virtual storage technologies are helping to control heterogeneous storage platforms.

The future cloud and data center model anticipates massive growth in the volume of data passing through the infrastructure. Moreover, software-defined technologies have become critical to the efficient delivery of next-generation content.▲

Denzil Samuels
Global Head of Channels, Alliances, Business Development, and Ventures for General Electric Digital

We're building an operating system that's going to power the Industrial Internet. That's our strategy. We want to be the owners of that space. >>

GE Establishes Multilevel Strategy in China

An ICT Insights Interview

On September 1 at Huawei Connect 2016 in Shanghai, ICT Insights Editor John North interviewed Denzil Samuels, Ph.D., Global Head of Channels, Alliances, Business Development, and Ventures for General Electric (GE) Digital.

Denzil Samuels says we're in the third wave of the Industrial Revolution. GE Digital is engaged to become a key force in the Industrial Internet for delivering innovations that increase productivity and reliability while lowering the cost of production and maintenance. What's more, Samuels says we don't have to wait until the next decade to see these changes — he says society is on the verge of this revolution in just the next two years.

The Industrial Internet combines digital information and communications with manufacturing and production. This allows businesses to make their assets more productive than they could before. Samuels says, "In the digital industrial world, the killer App is asset performance management." By incorporating digital monitors and data acquisition through the industry chain, businesses will have digital doubles to better understand product and service lifecycles from factory automation to predictive maintenance. Applied across your business, the result will be less downtime, increased productivity, and stronger growth.

ICT Insights: How would you describe the partnership between Huawei and GE Digital?
Dr. Samuels: We're thrilled with the partnership with Huawei and GE Digital for a number of reasons. One is, Huawei is such a pioneer in the whole world of ICT. And then to have someone that not only knows the local Chinese market — which I think is going to become one of our biggest markets — but also has global capabilities. This is exciting for us, so we're thrilled about the partnership and to be here today.

ICT Insights: Please share your thoughts on GE as a digital industrial leader, and tell us about your strategy.
Dr. Samuels: The GE Digital strategy is very simple. We think that the world of the cloud has come to a number of areas: the consumer world, which is dominated really by Amazon and Alibaba, and a few others. The enterprise Internet has been dominated these last few years by Salesforce.

But when you think about the Industrial Internet, who comes to mind? So we want to own that space. We're building an operating system that's going to power the Industrial Internet. And that's our strategy. We want to be the owners of that space.

ICT Insights: How can partners like Huawei work with GE to reach their goals and extend your influence?
Dr. Samuels: Huawei's instrumental in this because they can help us provide the infrastructure we need. Whether it's the data center infrastructure, the communication layer, or devices to reach this Chinese market — and not just the Chinese market, which I think of as Phase 1, but also extend our reach around the world. Because Huawei has expertise in this, we don't have to start from scratch. We start with a player that already understands and is already a world leader in the cloud space.

ICT Insights: How is GE changing the face of the Industrial Internet?
Dr. Samuels: In the past, if you bought an engine, what you bought was a jet engine. And maybe you got a maintenance contract on it, right?

ICT Insights: Understood.
Dr. Samuels: Hopefully you got a maintenance contract. When you have an engine that's digitized and connected, that's giving you real-time information about how it's performing. Every single blade on that engine has a sensor, so we know the wear and tear on that blade, whether it's flying over a desert sky in the Middle East or the cleaner air of the U.S.

So, if you're going to an airline and you're selling them an engine, you can actually sell them a business model — an engine that gives them real-time information that can affect crew scheduling, flight operations, cargo, maintenance schedules — everything.

So, if you're an airline, what are you going to buy? Are you going to buy just an engine? Or an engine that's talking to you and laying out everything so you can then map it into the other digitized part of your portfolio?

ICT Insights: And I imagine that capability extends across every product line.
Dr. Samuels: That's exactly right. It doesn't matter if it's a jet engine for airlines or it's in the power, gas and oil, or automotive industry. It extends to everything. The Industrial Internet, we think, is going to be bigger than the Industrial Revolution itself.

Think about the number of devices in the world that need to be connected and yet, today, aren't. We can't extract the information and the data that we need to be able to make those devices perform optimally.

ICT Insights: What's the expected impact of technologies like AI (Artificial Intelligence) and Big Data on the IoT ecosystem?
Dr. Samuels: I think we've already seen huge advancements in AI, and Big Data's been with us for a long time. In fact, if you look at the engine example I gave you earlier, one engine throws off a terabyte of data although we weren't thinking that way in the past. So, the way we have to think about AI, and the way it comes to Big Data is in three steps. First, you have to connect the devices. Then, from those devices you have to extract information and insights that you didn't have before. And then, based upon that information and those insights, you derive and drive actions that produce outcomes. So, really at the end of the day, what you are selling to a customer is outcomes.

ICT Insights: Right.
Dr. Samuels: Lower fuel consumption. Minimization

Ecosystem

In the digital industrial world, the killer App is asset performance management. It's taking an asset and making it a darned sight more productive than it was before you digitized it. I think big companies get that — they're doing it today. >>

of costs. Minimization of risks. 100 percent productivity, uptime. That's what we're selling.

In fact, in the digital world, one percent of productivity gains could be worth trillions of dollars, so it's an incredible opportunity.

ICT Insights: How do you see this progressing over the next five years? Where are we now, and when is the inflection point in that five-year period?

Dr. Samuels: I think that big companies are doing this today. If you think again back to the Salesforce example I used, the killer App that Salesforce sold was CRM — customer relationship management. In the digital industrial world, the killer App is asset performance management.

It's taking an asset and making it a darned sight more productive than it was before you digitized it. I think big companies get that — they're doing it today.

I believe the message that we're giving is, "if you don't figure out how to digitize your assets, someone else will, and they're going to make those assets more productive than you are." And so, I think we're going to see an acceleration of this within the next twenty-four months, not just over the next five years.

ICT Insights: What is GE Digital's strategy in China?

Dr. Samuels: We have a multi-level strategy in China. First and foremost, China is important to us. Why? When you think about the world's manufacturing, the largest number of manufacturers is right here in China. So, a lot of what we're doing is helping improve asset performance management in factories. You can't do that without building competencies locally. And you can't do that without a local ecosystem. So that's why we have great partnerships with China Telecom and Huawei. In addition to that, we're spending money. We've spent USD 11 million to build a foundry. And that foundry is going to spur incubators.

It's going to create development companies that will develop on our platform — Predix — and our operating system. And it's also going to allow us to bring customers in so they can develop along with partner-systems integrators, local and global, who can develop solutions for us and the Industrial Internet.

When thinking about China, our thoughts are: Establish a foundry, an ecosystem of partners, and a core competency of engineering and research and development talent that are ours to help fulfill all parts of this world that we're now moving towards. >>

So, when thinking about China, our thoughts are: Establish a foundry, an ecosystem of partners, and a core competency of engineering and research and development talent that are ours to help fulfill all parts of this world that we're now moving towards.

ICT Insights: Impressive goals.

Dr. Samuels: Yes. Impressive goals and impressive investment. We're spending a lot of money, and we will continue: We're going to spend another USD 20 million in the next twelve months to really take us to Phase 2. This is in addition to the investments we're making with our partners for all the technology of theirs that we need to leverage.

ICT Insights: What are the most interesting challenges that you're currently facing, and what solutions are you considering?

Dr. Samuels: I will tell you the biggest challenge we face is the old way of thinking. We don't see any other competitors in this space. We have been doing this for the last five years. There's a big cost of entry in doing this. GE's invested billions in this space, so we don't see anyone really trying to duplicate what we've done. We have too much of a head start.

It is the old way of thinking we hear from our customers. "Why do I need to move to the cloud right now? Do I trust my assets with a third party? Do I worry about data in the cloud?" That's really the challenge, and we have to break down those barriers. I think we're getting a lot of help from our partners, who understand that world, as well as from a lot of the regulatory authorities, who also understand that world — in fact, in some cases better than our customers.

So, I think those are the obstacles we face. We just have to establish trust. And, as people see the gains, it will help us propel this in the right direction, certainly in this local market.▲

Huawei and Accenture Team Up to Support Business Transformation in the Cloud Era

| By *Yu Hongbiao, Managing Director of the High-Tech and Electronic Industry in Greater China, Shan Yu, Strategy Consultant, and Kong Hui, Strategy Consultant and Analyst, Accenture*

Nowadays, the entire business arena is turning to digitization. Enterprises are adapting rapidly to changing market dynamics while being subjected to immense pressure to innovate. Under such circumstances, many enterprises are looking into cloud computing to enhance their flexibility in order that they may utilize minimal resources to meet market and customer requirements within the shortest time.

According to research firm Gartner, the size of the cloud computing market worldwide is expected to reach USD 204 billion, a 4.3-fold increase from USD 47 billion in 2008. While many regard cloud computing development as a stage of Information Technology (IT) evolution, it has fundamentally transformed enterprises — driving many to reconsider their IT and business development strategies.

Entering into the cloud era does not imply an across-the-board migration of all businesses and applications to the cloud. Before taking the first step of cloud transformation, enterprises must understand why they want to transform and what results they expect. According to Accenture's latest research findings, enterprises need to consider a few points.

Can cloud solutions:

- Help employees increase work efficiency and improve performance?
- Increase employee communication efficiency, help employees obtain information in real time, and collaborate seamlessly?
- Enhance your enterprise's capability of information collection and decision-support?
- Provide holistic channels for better interaction with customers and partners?
- Offer employees tools and channels to help effectively utilize enterprise resources?
- Help increase business agility and adaptability to satisfy customers' new requirements?
- Facilitate your employees to bring innovation to business opportunities, products, and processes?

By reflecting on these questions, enterprises can better understand their requirements for cloud solutions and select suitable strategies and technologies. Enterprises must then combine three cloud-based elements: Agility, X-as-a-Service (XaaS), and integration.

Yu Hongbiao

Shan Yu

Kong Hui

The enterprise cloud solutions launched by Huawei and Accenture help enterprise CFOs and CIOs cope with a series of cloud computing transformation challenges. These solutions will help global businesses in the telecom operator and enterprise ICT markets quickly adapt to the cloud era. >>

Quick testing, adaption, analysis, and cooperation are capabilities necessary to build a customized cloud environment that can satisfy an enterprise's business needs and external customers' requirements. Enterprises should apply the principles of XaaS to the entire business process, from delivering solutions to raising requirements for infrastructure service providers. As for integration, enterprises should always first consider the cloud when designing or rebuilding their applications to ensure that resources are allocated quickly through the cloud and to avoid excessive investments in the early stages.

Entering into the cloud era does not imply an across-the-board migration of all businesses and applications to the cloud. Before taking the first step of cloud transformation, enterprises must understand why they want to transform and what results they expect. >>

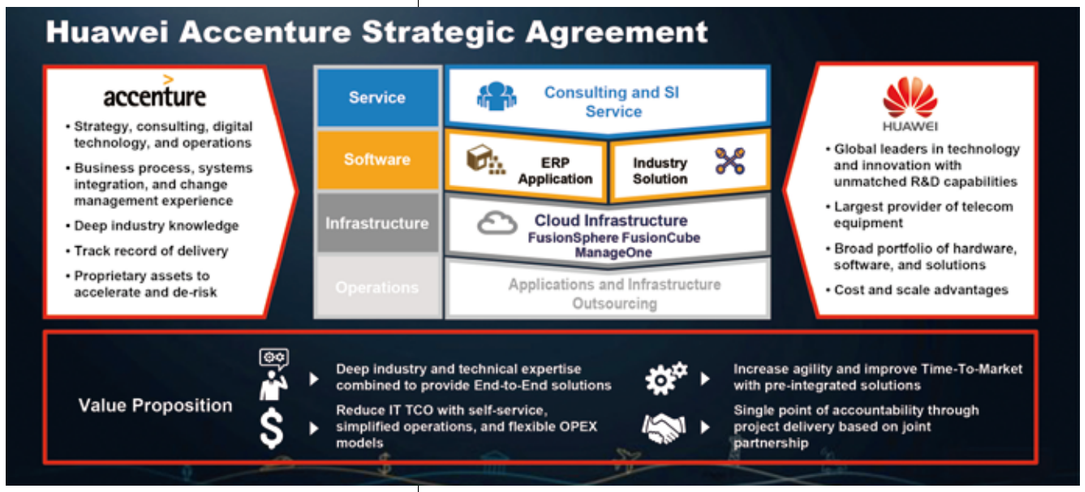
Huawei Teams with Accenture

In the cloud era, the problem is not whether enterprises should conduct digital transformation through cloud computing — rather, their focus should be on when and how to conduct digital transformation. To meet enterprises' increasing requirements for cloud computing and help them increase agility and reduce operating costs, Accenture and Huawei signed the 'Huawei Accenture Strategic Agreement' in October 2014. Both parties jointly develop and promote innovative solutions based on enterprise requirements for the telecom operator and enterprise ICT markets. Fully leveraging their strengths — Huawei's industry-leading software and hardware products and various solution packages along with Accenture's capabilities and its experience in consultation, digital technology, and operations — the Huawei-Accenture team provides global enterprises with predesigned and integrated enterprise cloud solutions based on Accenture's Infrastructure-as-a-Service (IaaS) solution and Huawei's cloud computing infrastructures.

Through this agreement, Huawei and Accenture complement each other. Huawei offers years of experience in product R&D and development in emerging markets, while Accenture is noted for its consulting service provisioning, implementation, and stable development in developed markets. For both parties, this presents a great opportunity to expand their business scope.

Harnessing the Cloud

The enterprise cloud solutions offered by Huawei and Accenture can help reduce total IT costs and increase Return On Investment (ROI) resolving the problem of low resource utilization rates caused by complicated IT environments, scattered resources, and fragmented management tools. More importantly, enterprises must deploy the needed intelligent infrastructures to support the operations of their key businesses to avoid service interruptions and security problems.



Enterprise cloud solutions combine highly integrated End-to-End (E2E) management solutions and Huawei's Data Center (DC) solutions with Accenture's intelligent infrastructure planning, cloud service capabilities, and industry technical experience. The solutions help enterprises improve DC performance, reduce operation costs, and simplify the IT environment. Currently, the Huawei-Accenture alliance provides four sets of application and industrial cloud solutions for enterprises:

- **Enterprise Private Cloud for SAP Solution** provides a platform for enterprises to deploy or migrate SAP ERP core components and business warehouse environments on or to the basic architecture of the hosted private cloud to build simple, low-cost, and effective systems. This solution supports the latest SAP technologies, such as HANA and Fiori.
- **Enterprise Private Cloud for Oracle Solution** significantly improves the efficiency of the Oracle operation environment and installs new business systems and modules. It also supports other Oracle eCommerce suites, Oracle Fusion applications, data analysis, and the mobile App.
- **S/4 HANA Migration** provides a highly regarded system migration solution with complete configurations for enterprises to realize quick migration while reducing costs and risks.
- **Enterprise Private Cloud for Telco Solution** combines Huawei's cloud infrastructures with Accenture's cloud services to help telecommunication operators utilize their IT resources to provide Business-to-Business (B2B) cloud services for enterprise and individual users and expand their business scope.

In the past two years, the Huawei Accenture Strategic Agreement has provided services for enterprises of many different countries and domains — from finance and energy to manufacturing and government — to help them take new steps towards digital transformation.

In China, Huawei and Accenture have provided enterprise cloud solutions for Guangdong Cable Co., Ltd., a large cable broadcast network operator in China. Huawei and Accenture deployed an integrated budget management planning and support system which helped the company standardize its budgeting processes, allocate resources more effectively, increase operating quality, improve business efficiency, and strengthen risk management and control across its entire operation.

Cloud computing has moved beyond large-scale enterprises to establish a new, cloud-based business ecosystem. All enterprises, regardless of scale, can profit from their position in the cloud ecosystem. >>

In the energy sector, the parties helped a large state-owned enterprise work out a DC strategy to ensure that the enterprise's IT systems could support the implementation of China's '13th Five-Year Plan.' By virtue of the cloud solution, the enterprise is able to more flexibly utilize their server and storage resources. They have also developed a stronger disaster recovery capability and reduced huge IT costs through centralized deployment and O&M.

Executives from Huawei and Accenture were not content with progress in the Chinese market alone and began to eye expansion outside China. In 2015, the two partners were awarded a contract by a telecommunications service provider in Malaysia to improve its activity management system by enabling the carrier to manage performance in real time.

Riding on that success, the parties utilized their resources to expand business to Europe, Southeast Asia, the Middle East, Africa, and Latin America. In 2016, the Huawei and Accenture strategic alliance leveraged solution centers in Shenzhen, Milan, and Manila where clients can develop solutions for specific requirements and better understand the end-to-end business benefits delivered through a cloud strategy.

Embracing the Cloud Era

In the initial stage of cloud computing, many enterprises were concerned about data security. With continuous development of cloud computing technologies, the potential of cloud computing has enticed more enterprises to utilize the cloud during data processing and information analysis. Cloud computing has moved beyond large-scale enterprises to establish a new, cloud-based business ecosystem. All enterprises, regardless of scale, can profit from their position in the cloud ecosystem. The digital trend in the business domain has built a broad stage for cloud computing. Looking ahead, Huawei and Accenture will make every effort to help enterprises quickly adapt to the cloud era. ▲

Hu Yueqing

Henan TV Streamlines Programming Over the Cloud

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

To meet the demands of Henan TV's expanding television audience, a unified cloud computing and storage technology platform has been built to support one of China's rich cultural centers. >>

Henan Province is a rich cultural center in China and home to Henan TV. The television station, headquartered in the city of Zhengzhou, broadcasts cultural programming that includes a traditional Chinese character game show, opera performances, and martial arts competitions, as well as other forms of variety entertainment. These shows retain high viewership and ratings from traditional culture lovers throughout China.

Growing Pains

Henan TV's production teams use Non-Linear Editing (NLE) for variety show production and to create new, more innovative programming. However, staff members were faced with serious equipment and networking problems, especially during peak season when NLE equipment rooms were packed with editors waiting for available workstations.

For variety show editors, creativity and inspiration determine the quality of programming. To improve quality, postproduction editors often go online to gain insights from viewer comments and reviews and to analyze Internet trends.

Most television stations with traditional network architecture separate their production network from their office network. This arrangement requires that editors change workstations to access the Internet, which lowers efficiency and slows down the editing and production process.

Cloud Producing

In October 2015, Henan TV launched its new HD production and broadcasting cloud platform using Huawei's cloud technology. The production of over 100 variety show programs and the compression and editing of TV series for all nine channels now run on a private cloud platform. Computing and storage resources are dynamically allocated between different services to separate them from devices, and editing is separated from rendering. The entire system cuts costs tremendously by using only about 30 blade servers compared to the more than 80 servers and 100 editing workstations in the traditional architecture.

Huawei used its experience with open clouds to develop a distributed media cloud Infrastructure-as-a-Service (IaaS) platform that supports professional video processing for radio and television services. The Information and Communications Technology (ICT) solutions provider also designed specialized optimization for different application scenarios on a universal ICT cloud platform.

Global Processing Units (GPUs) and other virtualization technologies used in video production typically present significant challenges to cloud computing. For instance, Henan TV uses 120 Mbit/s full-HD resolution for variety shows, with postproduction editing scenarios involving many special effects. These demands make the implementation of a universal cloud platform difficult.

For example, to resolve difficulties using Virtual Desktop Infrastructure (VDI) in the production or office area or for postproduction HD editing at home, Huawei enhanced its HDP desktop protocol. Smart recognition technology distinguishes the video, text, borders, menus, and lines processed using the NLE application software. Algorithms like H.264 video compression, LZ4 lossless text compression, and JPEG lossless image compression are then applied to corresponding video, text, and photos.

This process ensures picture quality while reducing the bandwidth and latency at the desktop end of the virtual machine for optimized editing. At the same time, when combined with optimized GPU virtualization technology, a single blade and K2 GPU video card can virtualize four HD editing cloud desktops, with each cloud desktop able to produce more than four tracks of 120 Mbit/s HD video as well as three tracks containing dynamic subtitles and lyrics.

Huawei has also provided a network adaptive technology that can dynamically and intelligently detect the status of the access terminal's network. Optimal picture quality is automatically adjusted according to bandwidth quality at home or at the office. In public networks, the desktop transport bandwidth can reach up to 5 Mbit/s. This means that Henan TV editors with 10 Mbit/s (or faster) fiber access in their homes can easily work on program production.

To ensure that multiple editors had a place to work after the deployment of the desktop cloud, Henan TV implemented a new pool-based HD NLE system. As long as resources are available in the NLE pool, editors can freely use any workstation. To maximize equipment usage efficiency and ensure that reporters off premises are still not occupying any NLE virtual workstations, Huawei's cloud management platform restores NLE resources back to the pool according to the configured policy. If the keyboard and mouse are idle for a predefined period of time, the platform determines that the reporter has left the NLE workstation and automatically saves project files using Sobey and Dayang software. The NLE workstation then logs out, and resources are returned to the pool.

A Future Transformed

The development of HD editing cloud desktops enables the production area for programming to expand into the office area and even into home-based workstations. This increases the efficiency of Henan TV's postproduction editors by providing them with smooth connections to the new media environment and station-wide network system.

Henan television production has come a long way since the Jet Li film *Shaolin Temple* was shot in Henan province back in the mid-1970s. As an advocate of traditional Chinese culture, Henan TV can now improve the efficiency of its production methods and create quality programs for an audience that will continue to grow. ▲

Success

In October 2015, Henan TV launched its new HD production and broadcasting cloud platform. The production of over 100 variety show programs and the compression and editing of TV series for all nine channels now run on a private cloud platform. >>

Robert W. Heath Jr

Nuria González-Prelcic

Vehicular connectivity has become a means for basic safety messaging and traffic management over the past 20 years, but now new sensors are equipping cars for an even better connected and safer driving experience. >>

Wireless Connectivity Takes Next-Generation Vehicles for a Ride

| By *Robert W. Heath Jr., Wireless Networking and Communications Group, Department of Electrical and Computer Engineering, University of Texas at Austin and Nuria González-Prelcic, Signal Processing and Communications Group, University of Vigo*

With wireless communication technology, applications support basic safety, transportation efficiency, and Internet access while vehicles communicate directly in Vehicle-to-Vehicle (V2V) mode or through the infrastructure in Vehicle-to-Infrastructure (V2I) mode (collectively called V2X). Connectivity is a natural complement to the increasing numbers of sensors that are integrated in automated vehicles.

Automated vehicles come in many flavors, depending on the automation level. One extreme is the driver in full control. At the other end, the vehicle is in complete control while the passenger has no means to take command. At levels in between, certain driving functions are automated, but the driver can still step in. For example, in a lower automation level, the driver may be warned about a potential forward collision. At a higher automation level, the car may automatically apply the brakes and take evasive action to avoid the collision. While there is a current trend to call fully automated driving 'autonomous driving,' it is unlikely that full automation can happen simultaneously with full autonomy, which implies no communication. Fully automated high-speed driving is difficult to achieve without (at a minimum) obtaining high-resolution map data via real-time updates from a map server.

Vehicular Sensing

Sensors deployed for automation include automotive radar, visual cameras, and Light Detection and Radar (LiDAR) systems. Radar is used for automatic cruise control, forward collision warnings, lane change assistance, parking, and pre-crash applications. Visual cameras are used for backup (in-reverse) safety, blind-spot monitoring, nap prevention, and lane keeping. LiDAR provides high-resolution 3D map information that can be used for autonomous navigation and pedestrian and bicycle detection.

These technologies are important for fully automated vehicles. For example, Tesla uses visual cameras for automated highway driving, while Google cars make heavy use of LiDAR and 3D map data for accurate driving and navigation, as well as several radar systems to aid in the detection of other vehicles. The range of each technology depends on its configuration and the deployment scenario. For example, in rural areas, the radar range is up to 200m, LiDAR's range is 35m, and the range for visual cameras is 30m, but in urban areas, the range diminishes to a few meters due to heavy traffic and other obstructions.

	Purpose	Drawback	Data Rate
Radar	Target detection, velocity estimation	Hard to distinguish targets	Less than 1 Mbit/s
Camera	Virtual mirrors for drivers	Requires computer vision techniques	100-700 Mbit/s for raw images, 10-90 Mbit/s for compressed images
LiDAR	Target detection and recognition, velocity estimation	High cost	10-100 Mbit/s

Table 1: Summary of Automotive Sensors and Associated Data Rates

Essentially, these external sensors are limited by what they can see. Communication may allow vehicles to expand their sensing range by leveraging what can be seen by other vehicles in the front, back, or sides.

The data that should be exchanged between automated vehicles is not yet determined. If only low data rates are available, it makes sense that vehicles communicate only heavily processed data. For example, a vehicle using its sensors may detect the presence of a bicycle and then broadcast the position and velocity of that bicycle to other vehicles. Alternatively, if high-data-rate communication is available, the vehicle may broadcast less processed or raw sensor information, allowing other cars to perform their own sensor fusion and processing. This method allows vehicles to make their own decisions, reducing the reliance on decisions made from other vehicles. An added advantage is that this approach scales as the processing capabilities of vehicles improve over time. Having high-data-rate and low-latency communication allows the exchange of processed and raw information. Table 1 shows the required data rate to transmit raw data generated from different types of automotive sensors.

State-of-the-Art Vehicular Communication

Dedicated Short Range Communication (DSRC) technology is primarily a means for exchanging basic safety messages and offers some applications in traffic management. DSRC supports both V2V and V2I. After nearly two decades in development, DSRC is now available in some U.S. cars; however, a government mandate is required for wider use. The data rates supported by DSRC are quite low — on the order of a few megabits per second. DSRC does not support the exchange of raw sensor data, which may be required by automated vehicles.

Cellular communication is another means for vehicles to communicate, either directly using Device-to-Device (D2D) or through the cellular infrastructure at the 850 MHz, 1,800 MHz, or 2,100 MHz bands. Through D2D mode in Long-Term Evolution-Advanced (LTE-A), the Base Station (BS) helps devices discover and communicate directly. The rates supported through D2D in LTE-A are limited due to the inaccurate channel state information, which is a problem in mobile settings. Fourth-Generation (4G) cellular communication is possible using this technology through the infrastructure, but data rates are merely several megabits per second in medium and high mobility. Table 2 shows the features of DSRC versus LTE-A for V2V/V2I communications. Considering that autonomous vehicles generate up to 1 TB per hour of driving, neither 4G cellular communication nor DSRC provides enough capability for connecting vehicles that want to exchange sensor data.

Connected-and-Automated Vehicles (CAVs) are a subject of huge interest. Currently, tests validate the advantages to combining connectivity and automation:

- Expanding vehicle sensing range, overcoming range limitations of existing sensors
- Supporting interactions between vehicles with different automation levels sharing planned trajectories so future decisions and actions are optimized
- More informed safety decisions and higher levels of traffic coordination and fuel efficiency

Sensing Challenges

At present, there is tremendous interest in the automotive use case for 5G. Applications include vehicular automation, transportation planning and operations, and infotainment. 5G will support 10x lower latencies and 10x higher bandwidths than 4G solutions, making it especially suitable for automotive applications. In particular, millimeter Wave (mmWave) 5G is attractive because of very high data rates, which can be used for exchanging raw sensor data. Moreover, high-data-

Sensors deployed for automation include automotive radar, visual cameras, and Light Detection and Radar systems. These technologies are important for fully automated vehicles. >>

Feature	DSRC	LTE-A
Channel Width	10 MHz	Up to 100 MHz
Frequency Band	5.86–5.92 GHz	450 MHz–4.99 GHz
Bit Rate	3–27 Mbit/s	Up to 1 Gbit/s
Range	Up to 1 km	Up to 30 km
Capacity	Medium	Very High
Coverage	Intermittent	Ubiquitous
Mobility Support	Medium	Very High
Market Penetration	Low	Potentially High

Table 2: Comparison of Different Features of DSRC and LTE-A in D2D Mode for Vehicular Communications

rate infotainment applications and joint communication and radar are possible at millimeter wave frequencies.

In mmWave links, vehicles and pedestrians may block the primary communication path, while static objects in the environment, such as trees and buildings, are another source of blockage. Assuming that the BS is equipped with different sensors, such as radar and cameras, a combination of sensing and Machine Learning (ML) detects potential obstacles and their associated mobility to help configure the communication link and improve V2I communication performance. The ML algorithm exploits past communication performance to classify particular radar responses as blockages, for example. Combined with the map of the static environment, this information is used to develop an algorithm to predict different types of blockages that a target vehicle experiences during travel. The results of the blockage prediction algorithm redefine the new beams that have to be used at the infrastructure side to illuminate the vehicle. The combination of

SAVES provides a common framework for the development of advanced vehicle connectivity, infrastructure to support connectivity, technologies for sensing, including imaging, radar and location, and applications of connectivity. >>

sensing and ML can also be leveraged at the transportation operations centers to discover more about the transportation environment and improve services related to traffic signaling and planning.

Precise localization is another critical aspect for autonomous or automated vehicle navigation. Standard GPS/GNSS receivers exhibit accurate 2- to 3-meter positioning under good multipath conditions, but autonomous/automated vehicles need a more precise positioning technology. Centimeter, or at least decimeter, accuracy is desired to guarantee that a vehicle keeps the security distance from other vehicles and stays in its lane. High-precision positioning, however, is challenging to navigate urban environments effectively due to the so-called 'urban canyon' effect between tall buildings. Although, precise receivers are available, the required GPS sensors are very expensive. One approach to overcoming these challenges consists of exploiting information obtained from other sensors in the vehicle or at the road infrastructure to correct the standard GPS-estimation and enable real-time, centimeter-accurate positioning.

Mixed-use environments, where vehicles comprise different levels of automation and communication, remain a challenge. One method is to deploy sensors at the BS and then the information derived from the sensors can be broadcast to connected vehicles, providing situational awareness about non-connected vehicles and non-vehicular users of roadways. The infrastructure-based

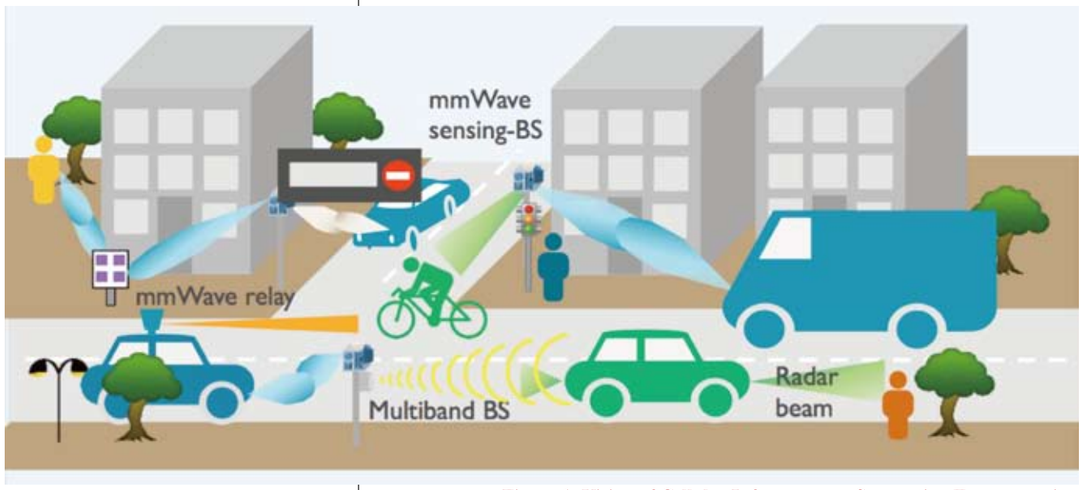


Figure 1: Vision of Cellular Infrastructure Supporting Transportation

approach works well even if most other vehicles do not have communication capabilities. Infrastructure also makes higher levels of automation more effective to coordinate interactions of vehicles through intersections without the need for traffic lights. This infrastructure-based sensing, as shown in Figure 1, will likely be built around 5G cellular communications since the aim is to provide much higher data rates. Figure 1 shows our vision of cellular infrastructure supporting transportation at mmWave. It is a combination of sensing, learning, and communication, where vehicles exchange sensor data.

Initiative SAVES

The University of Texas (UT) at Austin has created a new strategic research initiative within the school's Wireless Networking and Communications Group called SAVES to tackle the challenges related to next-generation connected vehicles. SAVES provides a common framework for the development of advanced vehicle connectivity, infrastructure to support connectivity, technologies for sensing, including imaging, radar and location, and applications of connectivity.

SAVES brings together companies working in communications and vehicular spaces with faculty and students who specialize in wireless communications, ML, and transportation. The SAVES effort also leverages ongoing collaboration with the U.S. Department of Transportation (DOT) through Data-Supported Transportation Operations and Planning (DSTOP) and numerous projects funded by the Texas DOT. A unique feature of SAVES is its emphasis on both wireless performance metrics, such as data rates, and transportation metrics, such as traffic efficiency and safety, when developing new technologies.

Current work being developed at UT

5G and mmWave communications will equip the next-generation of automated cars with more and more sensors. High-data-rate connectivity is critical to vehicles for exchanging sensor data, enlarging their sensing range, and making better safety-related decisions. >>

SAVES includes basic theory, algorithms, and experimental activities. One research direction aims to establish the fundamentals of sensor-aided communication and apply these fundamentals to beam training in mmWave V2X communication by leveraging data extracted from the many sensors available on cars. These include radar-aided mmWave vehicular communication and the use of position information to reduce beam alignment overhead.

Another research direction is the development of the basic theory for mmWave vehicular communications. The investigation of the optimum beamwidth and the definition of the coherence time for beam alignment are good examples of the projects already developed.

Several current and evolving experimental activities are making extensive use of National Instruments equipment that includes millimeter-wave prototyping and radar testing and measurement tools. Channel measurements — taken in collaboration with the Toyota Info Technology Center and National Instruments — are being conducted to better understand the mmWave vehicular environment. A hybrid mmWave prototype MIMO system with two RF chains providing 1-GHz bandwidth is being developed in a collaboration between UT, the University of Vigo (Spain), and National Instruments. The goal is to test our hybrid precoding and channel estimation algorithms in simple vehicular scenarios. A joint mmWave communication and radar prototype is also being developed based on National Instruments hardware; it leverages the waveform and the typical receiver algorithms of the IEEE 802.11ad WLAN standard to enable a joint framework of vehicular communication and radar technologies at 60 GHz. A similar effort is being conducted at lower frequencies to show how IEEE 802.11p could also be used for radar. Finally, there is ongoing research into data fusion based on experimental data; for example, combining DSRC and radar for improved forward collision warnings between connected and unconnected vehicles.

Conclusions

5G and mmWave communications will equip the next-generation of automated cars with more and more sensors. High-data-rate connectivity is critical to vehicles for exchanging sensor data, enlarging their sensing range, and making better safety-related decisions. Sensing is an important differentiating feature of vehicular systems, and sensing data can be leveraged not only to increase safety or traffic coordination levels but to aid communication itself, helping establish mmWave links with low overhead. Infrastructure becomes not just a means of communication but also a sensing and data collection platform. This data will be useful for real-time operations, transportation network control, planning, and operations. Many research challenges still need to be tackled, however, to implement our 5G automotive vision, including the development of the fundamentals of mmWave vehicular communications and sensor-aided communications. ▲

Chandra Krintz

Rich Wolski

Specifically, our system uses scalable key-value stores and caching, relational database, and high-performance search systems, as well as batch and streaming analytics frameworks to construct the PaaS service ecosystem. >>

PaaS Cloud for Integrated Full-Stack Monitoring

| By *Chandra Krintz and Rich Wolski, Co-Directors, Lab for Research on Adaptive Computing Environments, Computer Science Department, University of California, Santa Barbara*

Platform-as-a-Service (PaaS) is an increasingly popular technology for deploying web-accessible applications in the cloud. PaaS serves to hide execution details such as Operating Systems (OSs), resource allocation, network configuration, and service ecosystem management. It also automates load balancing, resource scaling, and fault tolerance. The result for application developers is the ability to focus on programming and innovation and ignore deployment and system issues.

The proliferation of PaaS technology has also intensified the need for new monitoring techniques, as effective monitoring is essential for facilitating auto-scaling, maintaining high availability, managing multi-tenancy, and identifying performance bugs in applications and the PaaS system.

Extracting sufficient insight from operating PaaS environments requires that the performance data be extensive and comprehensive, and that the process of data collection be efficient — with little impact on system performance. Therefore, the key to any successful Application Performance Monitoring (APM) system is to effectively resolve these challenges and their associated trade-offs.

Instead of an external system, our cloud APM system is tightly integrated with the PaaS cloud. We augment existing components to provide comprehensive, full-stack monitoring, analytics, and visualization.

This design takes full advantage of the scaling, fault tolerance, security, and control features of existing PaaS platforms while providing a low-overhead End-to-End (E2E) methodology for monitoring and analysis of cloud applications.

APM and PaaS Integration

Like most system monitoring solutions, our cloud APM features data collection, storage, processing and data analytics, and visualization.

Sensors and agents, which instrument the applications and core components of the PaaS cloud, collect data. While sensors are physically static, software agents are more complex and built to intelligently adapt to changing conditions. Since sensors and agents can impact behavior and performance, they must be lightweight and non-intrusive. To achieve this, we combine periodic, non-exhaustive sampling with the intelligent placement of sensors and agents throughout the software stack.

For performance data storage and processing, we leverage the scalable and highly available distributed services of the PaaS. Specifically, our system uses scalable key-value stores and caching, relational database, and high-performance search systems, as well as batch and streaming analytics frameworks to construct the PaaS service ecosystem. For portability across PaaS systems, each function defines an Application Programming Interface (API) through which it interacts with PaaS components and services. For porting to a new PaaS, API operations are rewritten and linked to those of the PaaS.

Figure 1 illustrates APM integration with a typical PaaS stack. The left (green) circles depict the PaaS architecture. Arrows indicate the flow of data and control in response to application requests. At the lowest level of a PaaS cloud, an infrastructure layer consists of the necessary compute, storage, and networking resources that the PaaS acquires and releases dynamically.

The PaaS kernel is a collection of managed, scalable services, which implement the common functionality required by most cloud applications. Application developers innovate by composing these services.

Increasingly, PaaS clouds provide a managed set of APIs (Cloud SDKs) used by developers to link PaaS functionality to applications. Cloud SDKs — like similar PaaS proxy mechanisms — simplify, control, and load balance access to PaaS services across applications and the system.

Application servers execute copies of an application and link the application code with the underlying PaaS kernel. The servers also isolate and sandbox the application code for secure, multi-tenant operations and to provide control and charging for services. Load

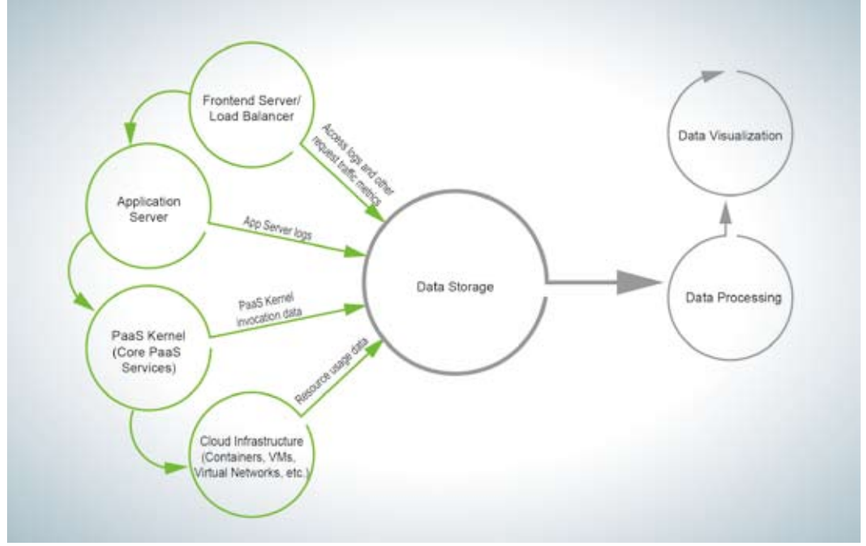


Figure 1: APM Architecture

balancers (or frontends) serve as the entry point to applications, intercepting application requests and filtering and routing them to the appropriate server instances.

Back to Figure 1, the small grey circles attached to the PaaS components represent the sensors and agents employed to monitor the cloud platform components to collect events and performance data. The APM collects data from all layers in the PaaS stack (full-stack monitoring). The rate at which measurements are taken is configurable and, in many cases, adaptive; moreover, sensors and agents use batch operations and asynchronous communication to reduce performance disruption and overhead.

From the frontend and load balancing layer, the APM gathers information related to incoming application requests. Monitoring agents scrape HTTP server logs to extract timestamps, source/destination addresses, response time, and other parameters. This information is usually readily available for harvesting as frontend technologies, such as Apache HTTPD and Nginx. Additionally, agents collect information about active connections, invalid access attempts, and HTTP errors.

Within the application server layer, sensors collect application and runtime/container log data, which typically includes the resource usage of individual application instances. Targeting log files avoids the high overhead of application and application server instrumentation.

Within the PaaS kernel, we instrument the entry points of all PaaS services:

- Collecting caller and caller information
- Timestamp
- Measured execution time per operation invocation
- Request details, including size and hash of the arguments

This helps distinguish different phases of PaaS execution; aggregates and characterizes operation invocation instances; and enables low overhead — yet accurate — full-stack monitoring.

From the cloud infrastructure, information related to virtual machines, OS containers, and processes and resource usage of each physical host machine is collected. Most sensors at this level scrape logs and query the Linux profile system, gathering metrics about the network, CPU, memory, and resource allocation and reclamation decisions made by the management and orchestration frameworks.

The collected information enables clustering-related activities and events across the system. Since PaaS systems commonly host web applications and services, our APM design considers web requests as events. A request identifier visible to all components is attached to each HTTP request header. The appropriate APM agents are then configured to record these identifiers. The data processing layer then clusters measurements by request identifiers to facilitate E2E system analysis for individual web requests.

The data processing layer stores and provides scalable access to this performance data. It also permits plug-in analysis routines that can be used to characterize application and system behaviors over time; detect behavioral and performance anomalies and workload changes; and identify opportunities for more effective resource utilization and automatic scaling of resources, services, and application instances.

These analysis routines perform inference and prediction and use statistical analysis libraries, batch processing services, and search and query systems.

ElasticStack as the APM Foundation

After a thorough evaluation, we chose ElasticStack to be the foundation for APM. ElasticStack is an open source distributed system built on Linux KVM

Hands-On Technology

Instead of an external system, our cloud APM system is tightly integrated with the PaaS cloud. We augment existing components to provide comprehensive, full-stack monitoring, analytics, and visualization. >>

After a thorough evaluation, we chose ElasticStack to be the foundation for APM. ElasticStack is an open source distributed system built on Linux KVM for data storage and processing. >>

(for Kernel-based Virtual Machine) for data storage and processing.

ElasticStack comprises three main components: ElasticSearch, Logstash, and Kibana.

- **ElasticSearch** supports scalable and highly available management of structured and semi-structured data via automatic sharing and replication and provides comprehensive data indexing, filtering, aggregation, and query support to simplify the implementation of our high-level data processing algorithms. ElasticSearch is integrated within popular Big Data workflows for advanced analysis.
- **Logstash** facilitates data extraction from a wide range of standard log formats.
- **Kibana** provides a powerful web-based dashboard and a wide range of charting, tabulation, and time series support.

APM Use Cases

The following use cases employ the PaaS performance data collected by our APM to provide new PaaS features. Of particular interest is how our APM system can help predict performance-based Service Level Objectives (SLOs) for web applications deployed in a PaaS cloud, and how performance anomalies are detected across the PaaS stack.

● Application Response Time Prediction

This APM use case provides scalable and accurate response time predictions that can be used between a cloud provider and PaaS user as a per-application SLO. To enable this, we combine static program analysis of the hosted web applications and APM monitoring of the PaaS cloud. Because we want to provide the prediction to PaaS users when they are deploying the applications, we perform this static analysis immediately prior to deploying or running an application on the PaaS cloud.

For each path through a function, our static analysis extracts the list of PaaS kernel calls (invocations and access to PaaS services) via traditional techniques for abstract-interpretation-based loop bounds analysis, branch prediction, and worst-case execution time analysis. To save overhead, we do not instrument the application to collect performance metrics at runtime. Instead, the lists are recorded in the APM system, and services are monitored in the system independently of the application's execution.

In particular, the system employs the PaaS kernel services performance data collected by the APM. An analysis routine then extracts a time series of operation execution times for each service in the list. A forecasting methodology then calculates statistical bounds on the response times of applications. These values are then used by the cloud provider as the basis for a performance SLO.

To make SLO predictions, we use Queue Bounds Estimation from Time Series (QBETS), a non-parametric time series analysis method we designed for predicting the scheduling delays of batch queue systems in high-performance computing environments. We adapt it for use 'as-a-service' in our PaaS APM system to estimate the response time of deployed applications.

Because PaaS service and platform behavior under load changes over time, our predicted SLOs may become invalid in time. Our system detects SLO violations so they may be renegotiated by the cloud provider. When such invalidations occur, the PaaS invokes our SLO analysis routine in the APM to establish new SLOs.

We have integrated our Cloud APM within the Google App Engine and have also integrated it into the full stack of the private open source PaaS AppScale. We use these platforms to perform extensive testing and empirical evaluation of open source Java web applications that execute over them. Our system generates correct SLOs in all cases.

● Performance Anomaly Detection

Our goal is to provide anomaly detection for PaaS-based (distributed) web applications. For this, we implement multiple APM analysis plug-ins called *anomaly detectors*. These processes periodically analyze the performance data for each deployed application in the PaaS.

Multiple detector implementations each use a different statistical method for detection. Detectors at the application level allow different applications to use one or more different anomaly detectors, each with an execution schedule and a sliding window of singly processed data; for example, from 10 minutes ago until now.

In addition, a path anomaly detector leverages the PaaS kernel call list for each request processing path through an application; however, in this case the data gathered from the PaaS kernel instrumentation (PaaS kernel invocation data) is used to infer the execution paths for individual applications. The detector computes the frequency distribution of different paths and detects changes in this distribution over time, identifies the occurrence of new paths (mostly executed paths), and significant changes in path frequency distribution.

Upon detection of an anomaly, the detector sends an event to a collection of anomaly handlers. The event encapsulates a unique anomaly identifier, timestamp, application identifier, and the source detector's sliding window corresponding to the anomaly. Anomaly handlers are configured globally but can be configured to ignore certain types of events. As with detectors, the APM supports multiple handlers for logging anomalies, sending alert emails, updating the dashboard, and so on.

- Additionally, we provide two special anomaly handler implementations: The workload change analyzer analyzes historical workload trends via a suite of change point detection algorithms, while the root cause analyzer evaluates the PaaS kernel call historical trends and attempts to determine likely components of the cloud (in the PaaS kernel) that may be attributed to a detected anomaly.

Anomaly detectors and anomaly handlers work with fix-sized sliding windows, discarding old data as the sliding window moves along the timeline. Historical data can be persisted in the APM for offline batch processing if needed.

Conclusion

As PaaS use grows in popularity, the need for technologies to monitor and analyze the performance and behavior of deployed applications has become essential; however, most PaaS clouds do not provide adequate support for lightweight, full-stack performance, data collection, and analysis.

While many monitoring frameworks have been designed to support data collection, storage, analysis, and visualization to varying degrees, none is designed to operate as part of a cloud platform. Data storage mechanisms, APIs, and configuration models are targeted at monitoring servers or applications as individual entities and do not support E2E tracing of request flows in a larger system. Further, they are not easily extensible, support only basic metric calculations, and provide no support for correlation or root cause analysis.

As a solution, we have proposed a new, easily integrated APM system that can take advantage of PaaS cloud features for comprehensive, full-stack monitoring and analytics. Our APM can be integrated into a PaaS system by customizing a set of API calls and can facilitate inference and prediction. Such functionality can be used to guide new PaaS services, including response time SLOs at application deployment time, system-wide performance anomaly and workload change-point detection, and root cause analysis for application performance anomalies. ▲

Hands-On Technology

The functionality of new APM system can be used to guide new PaaS services, including response time SLOs at application deployment time, system-wide performance anomaly and workload change-point detection, and root cause analysis for application performance anomalies. >>

Dragan Boscovic

Orchestrating a Symphony of Data

| By *Dragan Boscovic, Chief Executive Officer, VizLore, LLC*

VizLore software agents blend virtual sensors with IoT analytics to maximize business value. >>

The Internet of Things (IoT) creates a sea of data across networks, protocols, and devices. The piecemeal capture, normalization, and analysis of data will over time be impossible at scale unless analytics move to the edge and will only be effective if the computational environment is intelligent, context aware, and completely agnostic towards the underlying connectivity technology. Smart solutions will require development, not just of good analysis and logic but also of 'soft sensors' (virtual sensors) that can live inside and dynamically assemble across a common, resilient, smart platform to effectively tackle the complexities of the IoT.

VizLore, which specializes in multi-device management solutions, combines a potent blend of technologies to develop an agile IoT platform that creates and manages soft sensors across networks and devices and uses them to perform data analytics in an adaptive and scalable fashion. Soft sensors are elementary data analytics modules that are dynamically assembled into a distributed IoT data analytics platform to make data actionable. Examples include optimization, controlled operational processes, and workflows in a predictive and preventative environment.

VizLore has created a platform with real business benefits that internalizes complexity to provide ease of implementation and future-proof extensibility to users.

Data in the Digital Economy

In 2013, it was reported that a full 90 percent of the world's data had been generated within the previous two years. At the rate of 10 times more data every two years — a trend that has held true for the past 30 years — the same report today would state that 99.5 percent of all data has been created within the last five years.

This data comes from everywhere: social network posts, digital pictures and videos, banking and commercial transaction records, smartphone Apps, and sensors used to gather operational and contextual information. We are in the midst of a major technology revolution, and digitalization is now dominating every sector of the economy. This global trend accounted for 22 percent of the world's economy in 2015 and is expected to reach 25 percent by 2020.

These volumes of data make up what has been termed 'Big Data.' Data analytics are a fast emerging technology that creates business value by combining and analyzing past data sets to predict problems and propose actions for their mitigation.

Two Sides of the Same Coin

There are two kinds of Big Data use cases: 'Data-at-rest' scenarios involve historical data safely stored and easily accessible, and 'fast-data' scenarios that involve tapping into the value of data in motion. The IoT is more about 'data in motion' in which the mission is to capture and extract contextual value in real (or near-real) time.

Fast data is front and center in the world of IoT connected devices. The IoT gathers unprecedented amounts of data from disparate sources and by correlating systems, data, and people — often powered by Artificial Intelligence (AI) applications — to create solutions that are capable of fundamentally changing the affected organizations.

IoT analytics can leverage into business benefits in three fundamental ways:

- Automates manual and error-prone processes, freeing up resources to focus on the most valuable parts of the operation
- Strengthens the relationship between the company and its customers, bringing a deeper, richer understanding of customers' needs
- Upgrades the company's conventional business model by creating new revenue streams and pricing strategies; upgrades individual, one-time product sales to connected services that generate recurring revenues

Two Computational Strata

The IoT is poised to change the way we currently live, work, and play, as we will soon be surrounded by all manner of connected devices, sensors, wearables, and

appliances that will each come with their own set of functionalities. There is surely no guarantee that any two or more systems will know how to talk to each other or share data. To derive the expected long-term value from the IoT universe, VizLore is taking an integral approach to help make sense of it all. The way to do that is to implement a security-focused Software-Defined Networking (SDN) Platform-as-a-Service (PaaS) architecture that is designed to orchestrate the devices and flow of data across IoT networks.

The VizLore platform is physically divided into two computational strata: 'Edge computing' is applied and distributed across connected devices and networking elements to enable tactical processing of fast data and serve to improve service resilience; and 'Cloud computing' orchestrates distributed computing and service integration across the edge devices and performs strategic oversight and workflow control.

To improve the effectiveness of the IoT platform, VizLore uses an open, purpose-built SDN as underlying fabric on which the Edge platform rests. This SDN solution enables distributed data gathering and processing due to the following:

- Edge network devices, such as Wi-Fi, gateways, and sensors, require that SDN logic be closer to end users where response to specific events requires decisions faster than the cloud can process a response.
- The SDN control plane is used to dynamically assemble physical sensors and network performance data into soft sensor constellations.
- Scalable and versatile data analytics are achieved through juxtaposing soft sensors across devices, networks, and the cloud to provide actionable insights on system performance.

Keep IoT Data Flowing

When SDN is complemented with edge and fog devices, such as switches, firewalls, IP cameras, sensors, and Bluetooth beacons, it opens up a whole new world of possibilities for the creation of added-value IoT services. Since the software part of the network sits in the cloud, it can be easily updated and redefined to suit any future need and maintain security without the need of an IT person on premises. The fact that VizLore's SDN picks up sensory data across the connected devices means that it can compile information from different sources into soft sensors that can then be further combined with other soft sensors to provide actionable recommendations.

SDN fabrics that are deployed edge devices and coordinated from the cloud are able to conceal the complexities of IoT network management so that users are able to focus on optimizing their critical business processes. SDN fabrics enable soft sensors to transparently blend many different protocols and data formats, including Wi-Fi, ZigBee, AllJoyn, and Project Haystack, which can be found in complex use cases. SDN fabrics are able assemble these disparate sources into soft sensor networks managed through the API abstraction layer that is exposed to our cloud-based platform.

VizLore's IoT platform architecture is flexible and open, and allows various types of devices, sensors, appliances, and wearables to be interconnected. Data is extracted from the VizLore

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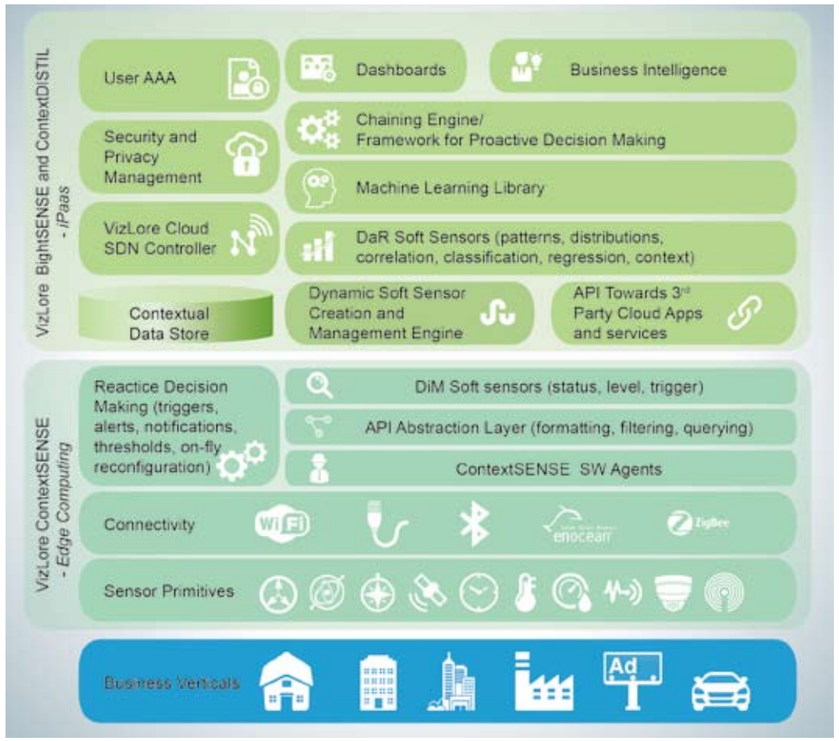
VizLore's IoT platform architecture is flexible and open, and allows various types of devices, sensors, appliances, and wearables to be inter-connected. Data is extracted from the VizLore system in ways that are ultimately useful to the end user. >>



Architecture of VizLore's IoT Analytics platform

system in ways that are ultimately useful to the end user.

Soft Sensor Stack

There are two categories of soft sensors: 1) those optimized for processing data in motion, called *DiM soft sensors*; and 2) those specialized in processing data at rest, called *DaR soft sensors*.

DiM soft sensors can be deployed on network and edge devices to enable collection, formatting, and analysis of all available contextual data. Networking elements include sensor primitives that provide data such as interface status (queue levels, signal-to-noise ratio, Tx/Rx bit rates, and packet drops), system status (CPU/RAM load, local storage, routing tables, and power consumption), and environmental status (connected devices, active/inactive links, and surrounding Wi-Fi networks). By combining sensor primitives, soft sensors are equipped to present contextual results without needing to perform post-processing on dedicated servers or SDN controllers.

In general, this approach requires the deployment of a software agent on each network device (Wi-Fi access point, distribution switch, or network router). The software agents are built to bridge the sensor primitive handlers for the Operating System (OS) of each device, such as OpenWRT (Linux), with the data analysis model of the soft sensor. The agents provide an abstraction of OS-controlled resources that data analysis processes can utilize without further formatting or preparation. Agents speed up data analysis and enable different software sensors (different data analysis models) to be deployed on different networking equipment. The main components of a software agent are:

- Software hooks for integration to expose the status and measurements on networking interfaces and other networking node resources, such as CPU and storage
- Buffers for sensory and contextual data necessary for accurate formatting
- Data formatting procedures to expose sensory and contextual data collected from the underlying OS to data analytics procedures of DiM soft sensors
- Action handler modules of the software agents to transform results of prescriptive analytics into configuration commands for networking nodes
- Query handlers to provide API elements that enable soft sensors to obtain formatted sensory and contextual data from the software agent's buffer

In SDN logic, a software agent is implemented either as a southbound API (if DiM soft sensors are implemented on the controller or networking device) or northbound API (if DiM and DaR soft sensors are deployed on the cloud or SDN controller with higher hierarchy).

There are different layers of soft sensors. DiM soft sensors are usually located on networking elements, and they are used for combining the analysis of measurements and inputs from sensor primitives, which is a function of the network element's OS. DaR soft sensors are deployed on the virtual network controllers that are hosted on cloud platforms. These DaR soft sensors combine results provided by DiM sensors, sensor primitives, and other sources of contextual data, such as web portals and open databases. They provide the deeper analytical insight that is necessary for proactive resource and service provision planning.

The figure (opposite) shows how different sources of contextual data and sensory measurements can be combined to create a layered structure of DiM and DaR soft sensors. Each next layer provides deeper analytical insight into network status, trends, state transitions, and correlations between network events. Layered assembly of DiM and DaR soft sensors is enabled via a well-defined Representational State Transfer (REST) API (the API abstraction layer). This allows deployment of soft sensors and prescriptive and predictive IoT data analytics when and where they are needed (depending on the services and application on a particular communication network).

Business Benefits

Many new modern services can be supplied through IoT analytics platforms, and the flexibility offered through a soft-sensor approach and two-strata architecture is designed to produce tangible business benefits. Adopters can:

- Expedite innovation, expand market reach, and improve customer experiences without necessarily increasing operational complexity.
- Continually monitor, analyze, and optimize development and manufacturing processes in support of optimized work flows and efficient operation.
- Manage a complex and ever-expanding portfolio of physical assets that are distributed across the globe and effectively supervise a growing ecosystem of supply-chain partners.

Sensors at Work

The challenge of detecting unauthorized wireless network routers has increased by orders of magnitude at a time when the verification of edge devices, sensors, and wearables is understood to be critical. In one 'smart' building deployment, VizLore has implemented 'Rogue AP detection' in the form of a composite soft sensor that detects unauthorized access points that might pose a security threat.

Users of IoT-enabled intelligent networks are limited only by their imaginations for building any new service or bringing old processes fully into the twenty-first century.

Stay Ahead of the Competition

Every forward-looking business has to develop new skills and organize its workflows around the IoT, Big Data, mobility, and cloud computing to preserve its competitive edge in this digital economy. To effectively exploit opportunities of the digital age, organizations must overcome the challenges of integrating data from multiple sources, automating the collection of data, and analyzing data to effectively identify actionable insights.

The VizLore soft sensor-based IoT analytics platform is well suited to address these challenges. We are prepared to equip both traditional and nontraditional players with the necessary means to address the disruptive opportunities that are forecast by these trends. It is important to remember that the IoT is about the data, not the devices. Data is the twenty-first century's primary raw material — and as always, raw materials represent great potential value. Collect data responsibly, handle it efficiently, and learn to work with it on a broad scale. Do not over-plan: Face the future head-on and engage! ▲

Hands-On Technology

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Joe Weinman

ICT technologies enable digital business strategies — or digital disciplines — that focus on differentiated processes, products and services, customer relationships, and innovation. >>

Business Strategies for the Cloud Economy

| By *Joe Weinman, Author, Cloudonomics: The Business Value of Cloud Computing and Digital Disciplines: Attaining Market Leadership via the Cloud, Big Data, Social, Mobile, and the Internet of Things*

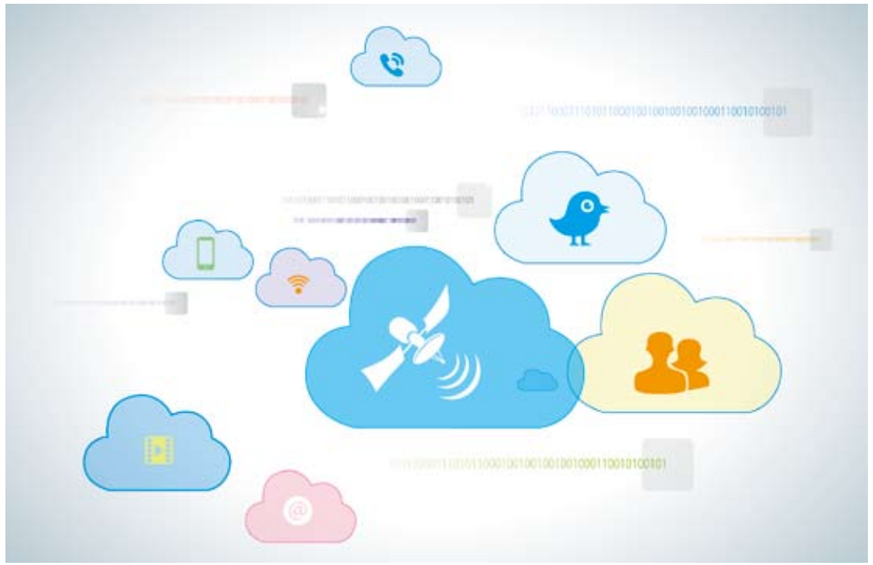
It is easy to see that digitalization is impacting businesses and society in an exponentially increasing fashion. It's equally easy to get caught up in the complexities of digitalization — hybrid clouds, containers, Solid-State Drives (SSDs), Software-Defined Networking (SDN), and Network Functions Virtualization (NFV) — and lose sight of the bigger picture: Technologies only matter in the context of creating differentiated customer value and enhancing competitive advantage.

Consequently, rather than starting with a technology and then asking what business initiatives that technology can enable, it is advisable to develop a focused business strategy with an understanding of stated and unstated needs and wants of customers, the evolving global competitive environment, critical industry trends, and existing competencies and market position. Technologies and other business system elements, such as culture, organization, and metrics, can then be structured to support the business strategy.

Four Strategies

I've identified four generic business strategies enabled by today's ICT developments, such as the cloud, Big Data and analytics, social, mobile, and the Internet of Things, which I call *digital disciplines*.

- **Information Excellence** complements, supplants, and drives operational excellence to enable cognitive computing or robotic automation of processes; optimization algorithms to enhance process performance; the seamless fusion of online and offline experiences; and the creation of highly dynamic value networks of suppliers, partners, channels, and customers.
- **Solution Leadership** represents a new generation of products and services that are smart, digital, and connected to the cloud. Being cloud-connected creates unique customer value and enables businesses to climb the experience-economy hierarchy from lower value commodities to products, services, experiences, and ultimately transformations, where each layer drives greater customer value and greater profitability.
- **Collective Intimacy** represents the evolution of traditional customer intimacy, from humans to algorithms and from in-person and face-to-face relationships to virtual and remote ones. This is more than a transition from offline service delivery to online commerce and social media. Collective intimacy uses Big Data and recommendation engines to consider all data collectively, which enhances each relationship with individualized, contextualized products and services.
- **Accelerated Innovation** is important because customers value companies that demonstrate a commitment to future improvements. ICT can not only accelerate the development of new outcomes, but new ICT inventions can also simultaneously reduce the cost and increase the quality of products and services in the market because of past developments that have enabled and mediated crowdsourcing, idea markets, contests and challenges, innovation networks, and rapid prototyping. Increasingly, and ultimately, computers are being programmed to innovate with a minimum of human collaboration.



Strategies in Action

● Information Excellence

Information and ICT can be used in many ways to automate, complement, supplant, mirror, or optimize processes and resources across a variety of industries. For example, shipping port operations offer immense opportunities for exploiting Information Technology (IT) to optimize the transfer of freight between land and sea-based vessels, improve throughput, reduce labor costs, increase sustainability, and improve on-time delivery of goods. This requires a real-time system that can ingest and manage constantly changing information, such as ship arrival times, truck and rail status, and container locations at the port, as well as external data such as weather forecasts and traffic congestion.

Fusing the worlds of information and operations is a concept that applies across verticals. Although the Internet is transforming education, the most successful initiatives must provide Online-to-Offline (O2O) integration, where online educational content and testing holistically relate to classroom activities. Banking 3.0 requires the same O2O integration via omni-channel integration of physical branches with online banking, particularly mobile.

● Solution Leadership

Products are becoming smart and cloud-connected to ecosystems across broad value chains. Vehicles, too, are connected to the cloud and to each other. Thermostats are not only adaptive but because they are also connected, they can be remotely controlled by residents in advance of arriving home or coordinated dynamically with smart energy grids. Wearables and the new generation of 'connected' apparel enable the monitoring, tracking, and linking of exercise activities to results, such as body fat loss and weight reduction.

Services are becoming smart, digital, and cloud-connected as well. For example, Zhengzhou University Hospital, in China's Henan province, has become a leader in telemedicine. The hospital has deployed teleconsultation devices in over 100 counties, enabling tens of thousands of remote consultations and diagnostics. Remote emergency care, imaging, diagnostics, and other services are possible because of the wide-scale deployment of cloud platforms and optical networks.

Solutions that consist of connected products and services provide a 360 degree view of each customer. Although individual radiological equipment is calibrated to deliver a safe dose of radiation to each patient, combinations of X-ray machines, Computed Tomography (CT) scanners, and other radiological equipment require a connected solution like GE's DoseWatch to deliver a patient-centric view. Similarly, in financial services, traditional silos for checking accounts, personal loans, mortgages, and equities must be broken down and integrated to develop a holistic view of each customer's financial health.

New ICT technologies are enabling entirely new business models. Automobile insurance premiums, for example, have traditionally been based on

Speaker's Corner

"I've identified four generic business strategies enabled by today's ICT technologies, such as the cloud, Big Data and analytics, social, mobile, and the Internet of Things, which I call digital disciplines." — Joe Weinman. >>

As the world becomes globally hypercompetitive, innovation is critical to even surviving, much less thriving. ICT can be used to make innovation faster, cheaper, and better. >>

static, historical demographic data, such as driver age, gender, home address, and prior violations, along with automobile make, model, and year. Now, Pay-As-You-Drive (PAYD) insurance data using telematics from smart, connected vehicles can determine insurance premiums based on real-time, actual driving behaviors and conditions, from speeding to traffic congestion among others. Furthermore, these premiums can be rated, billed, and paid in real time, mile by mile. In North America, growth projections regarding such policies indicate a Compound Annual Growth Rate (CAGR) of 50 percent over the coming years.

● Collective Intimacy

Customer intimacy entails deeply understanding the needs and wants of a customer — whether a business or consumer — and then meeting those needs. This is the exact inverse of mass production approaches, such as the first Model T cars in which all customers got exactly the same car, in any color they wanted — so long as it was black. Customer intimacy is practiced by tailors, hairstylists, physicians, and bartenders, who, of course, customize the fit, hairstyle, treatment, or drink order based on the customer's needs and desires.

However, customer intimacy is yielding to collective intimacy. Rather than individual pairwise relationships between consumers and human service providers or business customers and human account teams, data from all customers is processed by sophisticated algorithms to better derive finely personalized and contextualized recommendations to customer groups with the same preferences.

Netflix offers an excellent example of collective intimacy, using the following customer information:

- **Intent**, based on what they've searched for
- **Behaviors**, including the movie titles or images that they click on (when determining what to watch) or the portions of a movie that they watch, skip over, or watch again
- **Contexts**, such as whether the movie is being viewed on a mobile device or a family TV, the time of day, and the geolocation
- **Demographics**, such as the age, gender, and home residence of the subscriber
- **External data**, including movie titles, language, actors, locations, and genres

It takes trillions of such data points, across all subscribers, to generate personalized recommendations for each subscriber, including the 'micro-genres' that are displayed to users — for example, 'quirky romantic comedies' or 'cerebral science fiction' — and the particular movies displayed in each micro-genre. It balances opposing objectives, from presenting movies with wide appeal to ones targeted to specific subscribers.

In healthcare, the Mayo Clinic does something similar by maintaining massive repositories of genetic, epigenetic, and microbiomic data. The Minnesota-based clinic also maintains pharmacological efficacy data, which details the effectiveness of each drug based on individual genetic profiles and medical diagnoses to deliver personalized therapies and medicine. Stated another way, data sourced collectively is used to deliver unique, individual treatments.

Broadly speaking, collective intimacy entails moving from a product-centric view to a customer-centric one. For example, retail banking clients are coming to expect personalized products, as measured over social media networks. Increased personalization can dramatically increase key business outcomes, such as the size of deposits, use of payment products, and overall bank revenue.

● Accelerated Innovation

As the world becomes globally hypercompetitive, innovation is critical to even surviving, much less thriving. ICT can be used to make innovation faster, cheaper, and better.

Most IT organizations are adopting approaches like agile development and DevOps to increase the speed and flexibility of development processes; however, ICT can enable innovation well beyond the IT organization and can thus have an even more dramatic impact, thanks to crowdsourcing, idea markets, contests, challenges, innovation networks, and other approaches.

As one example, GE used the cloud to run several online contests including *Flight Quest I*, with the intent to better predict flight arrival times, and *Flight Quest II* to optimize flight paths and thus the passenger experience. To do this, GE published a number of Big Data sets on weather conditions, scheduled arrival times, and actual arrival times, and then opened up the contest to anyone in the world who wanted to solve it. One million dollars in prizes were awarded to a variety of teams, which used sophisticated statistical methods to innovate new algorithms.

Fold.it was a project set up at the University of Washington by professor and researcher David Baker to determine the structure of a disease-causing protein: Mason-Pfizer Monkey Virus (MPMV) retroviral protease. To attract as many people as possible to their cause, the developers implemented gamification to make the online contest more engaging to the general public. The protein problem, which had eluded a solution by the world's top biomedical researchers for 15 years, was solved in three weeks by someone who knew nothing about proteins or viruses or biochemistry.

We are also now entering an era in which innovation is not just a human endeavor — but one where machines are performing increasingly larger roles. For example, Google's DeepMind AlphaGo program made headlines around the world when it beat the world champion Go player Lee Sedol of South Korea, 4 games to 1 in March 2016. AlphaGo does not use a 'brute force' recursive examination of the all possible responses to all possible moves. Instead, it 'learns' to play through 'deep' Machine Learning (ML), in effect, mirroring the neural network approaches that we humans use to learn things, including language, abstract thinking, and, of course, the game of Go. Perhaps most interesting is that AlphaGo innovated new strategies and moves. In Game 2, Move 37, the program made a move that most game observers thought was a mistake, perhaps due to a bug in the program. It was only many moves later that the beauty of this innovative move became clear: It was a key move leading to a positional advantage and, ultimately, the program's victory.

Machine innovation isn't just happening in games. Melvin is a software program for quantum physics that takes common building blocks and designs new experiments, a notoriously tricky activity due to the inherently non-intuitive behavior of the quantum realm.

Making the Right Calculations

Revered Chinese general and philosopher Sun Tzu said an army that is strong on the left is weak on the right; one that is strong on the right is weak on the left; and one that sends reinforcements everywhere is weak everywhere. To apply these teachings implies that a firm should first focus on a single *digital discipline*, say, information excellence or collective intimacy.

However, information economics is different from military tactics. For a company in any industry today to be as successful as a great army, it cannot be weak in any area and perhaps must be strong in all digital disciplines. Thus, we see some leading companies exploit ICT to optimize their processes through information excellence; create industry-leading products and services through solution leadership; enhance customer relationships and the customer experience through collective intimacy; and accelerate innovation.

Sun Tzu also said that the general who wins a battle makes many calculations before the battle is fought. What is your digital strategy?▲

Speaker's Corner

We are also now entering an era in which innovation is not just a human endeavor — but one where machines are performing increasingly larger roles. >>

Diana Yuan

By joining forces with a collaborative community of developers, ICT vendors can connect with a vast pool of knowledge, expertise, and ideas to develop innovative solutions that meet the specific needs of customers. >>

Leading New ICT: An Open Innovation Era Defined by Developers

| By *Diana Yuan, President, Marketing and Solution Sales, Enterprise Business Group, Huawei Technologies Co., Ltd.*

For many years, enterprises have deployed technology to improve efficiency, enhance products, and drive new business models. Leading new Information and Communications Technology (ICT), such as the Internet of Things (IoT), cloud computing, and Big Data analytics, now presents major new challenges and opportunities for enterprises across industry sectors.

The banking industry, for example, is undergoing profound change from digital disruption. Banking customers now expect anytime, anywhere connectivity with access to personalized services, forcing banks to speed up the delivery of new digital products and services.

In this new era, speed of innovation is critical to keep pace with new market entrants, emerging technologies, and changing customer expectations. To effectively respond to these new dynamics, the ICT industry has evolved from being *hardware-defined* to *software-defined*, and now to *developer-defined*.

In this environment, all players across the ICT supply chain are expected to create value by addressing evolving business needs in various industries. With their deep understanding of consumer behavior and industry-specific and cross-industry trends, software and application developers are increasingly on the frontline of these industry changes.

Rather than relying solely on traditional channel models, ICT vendors need to think expansively and work with developers and partners through an open ecosystem to drive the development of leading new ICT solutions.

ICT vendors have the technology capabilities to develop advanced infrastructure but often lack specific vertical industry expertise or knowledge. For instance, an ICT vendor may have mature infrastructure solutions that have gained tremendous traction in the healthcare industry and is looking for growth in the financial sector but is unfamiliar with regulations in that industry. By joining forces with a collaborative community of developers, ICT vendors can connect with a vast pool of knowledge, expertise, and ideas to develop innovative solutions that meet the specific needs of customers.

Vendors such as Huawei are partnering with developers throughout the global ecosystem to create ICT solutions and platforms that enable enterprises to enhance core offerings, introduce new applications, or expand into new markets.

Embracing a Developer-Defined Ecosystem

Developer-defined ecosystems create business innovation for customers and solution innovations for partners, delivering win-win scenarios for everyone. But transitioning to this new era requires a change in the way ICT vendors and partners work together to drive the development process toward more innovative and diversified business solutions.

In the traditional development model, collaboration meant partners merely extended basic vendor capabilities. In the new developer-defined ecosystem, partners are now demanding innovation from the vendor community based on end-user requirements, and together they are delivering cutting-edge solutions.

Openness is in Huawei's DNA, and its '*1 + 1 > 2*' partner program is designed to harness the expertise of each party to achieve winning outcomes. One such example is the SAP-Huawei joint innovation center, which was established in 2015 with locations in Shenzhen, China and Walldorf, Germany to extend SAP HANA solutions into the cloud, Industry 4.0, and the IoT.

Huawei has been involved in a number of in-depth IoT technological collaborations with global industry partners. For example, Huawei and Intel are collaborating to introduce 'smart' bus solutions in Dubai to promote the more efficient use of public transportation.

Intel's x86 platform in Huawei's IoT gateway designed for the smart bus solution will allow a multitude of intelligent services, including in-vehicle video surveillance, accurate passenger tracking, emergency services communication, real-time vehicle health analysis, and multimedia services for passenger entertainment.

The ultimate goal of IoT deployments is to reduce costs and resource consumption, enable more effective engagement with people in the community, and enhance performance and public well-being.

Huawei is committed to working with developers and partners to create customer-driven ecosystems with its open ICT platforms that unleash new opportunities for every industry. >>

Opening the Door to Innovation with Open Platforms

Huawei provides an open ecosystem and a broad portfolio of ICT solutions for developers and partners around the world, enabling them to create enterprise-ready applications with Huawei tools and support.

The Huawei enterprise Software Development Kit (eSDK) platform provides partners with open Application Programming Interfaces (APIs) and preintegrated plug-ins for developers to easily integrate Huawei ICT pipeline products with upper-level applications. This platform helps partners to efficiently meet customer service needs and gain a differentiated competitive edge. For example, cloud government solution provider Esri uses eSDK open interfaces to accelerate project development, thereby bringing government customers the benefit of convenient, easily maintained cloud services.

Huawei's OpenStack-based FusionSphere cloud Operating System (OS) builds an agile and secure cloud infrastructure that seamlessly runs computing, storage, and network resources from different vendors.

By providing a complete cloud offering that includes Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS) solutions, Huawei helps enterprises transition to the cloud and implement superior, real-time customer service and business innovation.

Huawei is a significant contributor to international open source communities that are driving the transformation of traditional enterprises and industries. Huawei has a long history of sponsoring foundations, projects, and conferences that promote leadership across the ecosystem.

In 2015, Huawei became a Platinum member of the Linux Foundation, and in 2016 was elected as a Gold Member Board Director for the OpenStack Board. In the area of Big Data, Huawei has made significant contributions in the development of the Hadoop project and continues to be a major force for the implementation of large-scale Spark deployments.

Developer-Defined ICT Innovation

Businesses and industries across all sectors are experiencing digital disruptions that are redefining customer expectations and reshaping industry boundaries. The leading companies in this new world need to accelerate digital transformation through leading new ICT and extending their technology and business capabilities through strong collaborations that are focused on achieving true innovation.

The shift towards a developer-defined ecosystem has the potential to force greater fusion in the ICT industry, not only to drive innovative ICT but also to create a more connected digital marketplace in which commercial and economic value is driven increasingly by information-based services.

Huawei is committed to working with developers and partners to create customer-driven ecosystems with its open ICT platforms that unleash new opportunities for every industry. ▲

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