Celebrating

25

Years

A retrospective on innovation in the telecoms, media, and technology sector

Cartesian®

This retrospective is dedicated to all our staff – past and present.

Foreword

A little known fact about Cartesian is that our company was founded the same year that the World Wide Web was invented. Some of our staff began their careers in the communications sector long before that time. But there are also many who have spent our whole professional careers in a period of rapid technological change.

It has certainly become a more connected world – opening up new opportunities and enabling us to cross physical and cultural barriers. At the same time, these changes have brought multiple challenges, and we constantly need to keep up and adapt. New business models emerge, some break, and others are re-invented. New social norms are established and previous ones become obsolete; we've created new etiquette for emails, mobile phones, and social sharing. The job market is different and requires new skills and methodologies, and so we are adjusting and learning new things all the time. You see, machines aren't the only ones that are learning – we are too.

Cartesian is a company of problem solvers who enjoy being part of building, enabling, and managing the changes our clients face in our increasingly connected world. Our enthusiasm for new technologies, systems, and approaches have us often remembering how things used to work. Thinking about the last few decades can have you shaking your head in wonder.

So last year, we asked our consultants to reflect on the telecoms, media, and technology sector, and write about how those subjects have changed over the last 25 years. This book is a collection of their stories and ruminations. We hope you enjoy it.

Peter Woodward, CEO

Areas of Innovation

25 Years of Innovation:

Voice Networks

by Ron Angner

How much data?:

Information	Approximate Data
A telegram	100 bytes
A typed page	10 kilobytes
A digital X-ray	10 Megabytes
100 meters of shelved books	10 Gigabytes (10,000,000,000 bytes)
The printed collection of the US Library of Congress	10 Terabytes (10,000,000,000,000 bytes)
All global research libraries	10 Petabytes (10,000,000,000,000,000 bytes)
All words ever spoken by human beings	5 Exabytes (5,000,000,000,000,000,000 bytes)

The growth of effective capacity to exchange information worldwide through two-way telecommunication[i]:

1986
280 Petabytes
2 newspaper pages per person per day

1993
470 Petabytes
3.4 newspaper pages per person per day

2000
2.2 Exabytes
Almost 16 newspaper pages per person per day

2007
65 Exabytes
6 full newspapers per person per day

2016
1.3 Zettabytes
120 full newspapers per person per day

Voice Networks

In this retrospective article, Ron Angner takes us to a telco's central office (a.k.a. telephone exchange) where we see the change in technology over the last 25 years. From floors of noisy equipment to today's software in the cloud, network technology has transformed from the physical to the virtual.

Now You See Me, Now You Don't – The Journey of Switching Office Technology

The first time I walked into an Electronic Switching System (ESS) office the quietness was deafening. I remember saying to myself, "Wow, this is so quiet!" Not only that, but it provided two to three times as much switching capacity as the old legacy technology. Equipment that use to take up floors of a central office was now being provided on a single floor – and sometimes less. The old legacy technology of course was the step-by-step and crossbar-switch technology.

Before I go on, let me briefly explain: network switching technology enables us to make those calls (and nowadays, texts, video, and more) that connect us to our loved ones from handset-to-handset. There used to be a lot of hardware to make that happen.

By 1991, ESS offices were a common sight. Wireline operators had already replaced most of the old mechanical switches and with it, a change in skills too. Before, switch technicians had to be mechanically inclined to keep things running smoothly. Now, the new breed of technicians had to be savvy with electronics and computers.

With electronic switching came speed in call completion and an incredible set of new services. Local service completion was always 'somewhat fast'. Now with computers in the network, coast-to-coast calls could be completed in just milliseconds. With computer technology in the signaling systems (SS7), signaling control points (SCP) and the signaling transfer point (STP), calls could be moved about and routed in what seemed like instantaneously. Imagine a call going from coast-to-coast could receive routing information from three or four sources as it made its way across the United States.

The 'electronics age' of the 90s brought an entirely new set of services to both residential and business customers. Features such as speedy touch-tone dialing, voice mail, call transfer and hold amazed the consumer while toll-free numbers, VPN, SDN and other services completely changed the way businesses operated. Toll-free 800 number services, for instance, routed calls from anywhere in the country to a common point by performing a computer data base "dip" to determine routing information – in the mere flick of an eyelash.

In the late 90s a funny thing began to happen in networks – as the Internet exploded, suddenly there were little gremlins, known as packets, running about at great speeds and taking up more capacity than voice calls. This was the advent of the second transformation in switching – the introduction of Internet Protocol (IP) technology. All of a sudden voice and data could be intertwined and carried over a common platform – the IP network. Voice was being whisked around networks in packets with quality equivalent to that provided by the legacy switched network. The concept of Voice over IP (VoIP) was with us.

So walk with me now into one of the industry leading switching offices – or is it even a switching office anymore? We walk into the office and what do we see? Do we see the lineup of frames that used to make up the electronic switching system? The STP or the SCP? No, we see a series of computer-like boxes that people call "soft switches". IP switches that are completely changing the technology landscape. Good hot, strong coffee is always available in these offices, so let's grab a cup and talk to the tech. As we talk to some of them, they talk of Media Gateways, Media Gateway Controllers and Session Initiation Protocol (SIP). We begin to realize that they are actually software technicians – what is this world coming to?!

But it's not just the electronics in the network that are providing major changes for consumers and businesses. With VoIP, carriers can replace the aging copper lines in the access network (from the central office to the customer premises) with shiny new fiber. Those copper lines were spec'd to carry voice frequencies from 300 - 3000 Hz. The fact that they can now also be used for broadband is amazing, but fiber is faster still and much cheaper to maintain. Many carriers have plans in place to replace the

majority, if not all, of their copper plant in the next 5 – 7 years. Looking back over the years, it was almost unimaginable to think of a tiny thread of glass carrying gigabits of information. It's a world away from when the telephone lines to homes and business were the battleship grey lines coated in lead – and that did not even keep the squirrels at bay!

As we return from the break room, I see papers spread out all over the technician's desk. I turn to the technician to see what this is all about and he says, "This is the project plan I have been given to implement."

In addition to the project documents, I also see lease termination agreements. In amazement, I turn to the technician and ask, "Where is everything going to go if you are moving out of this building?" With a grin on his face, he says to me, "It is going to the cloud – we are moving to the virtual world now."

Enter network virtualization, the third transformation of switching which is just starting to take hold: the Central Office Re-architected as a Data Center (CORD). Vendors are virtualizing the functions of today's soft switches so that they can run as software on generic computer servers. Using new technologies such as Software Defined Networking (SDN), Network Function Virtualization (NFV), and Lifecycle Service Orchestration (LSO), CORD promises to free operators from the inflexible networks and tap into the elastic, scalable, agile world of cloud computing. In this new world there's no need for customized switching equipment. So, you ask, what is left in the central office?

Well, in spite of all the virtualization and everything else we have accomplished, there's still a need to connect all of the lines (or fibers) from customers back to the network. The physical layer of the network is the component that will be left in what used to be called the central office. This means that you're still going to need some technical sites, just less of them and without the huge space and power requirements of the past.

So, on our journey, we went from floors of mechanical equipment to a single floor of electronics and then to virtual elements in the cloud. Along the way, operators have reinvented their networks to add features, reduce costs and launch new services. One wonders what networks will "look" like and what they'll be able to achieve in the next 25 years? <>

Note:

[i] Bunn, Julian, "How Big Is A Petabyte, Exabyte, Zettabyte, Or A Yottabyte?", Globally Interconnected Object Databases. September 2012; Hilbert, Martin and Lopez, Priscila, "The World's Technological Capacity to Store, Communicate, and Compute Information", ScienceMag.org. April 2011.

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world around you on Faceb

See photos and updates from friend

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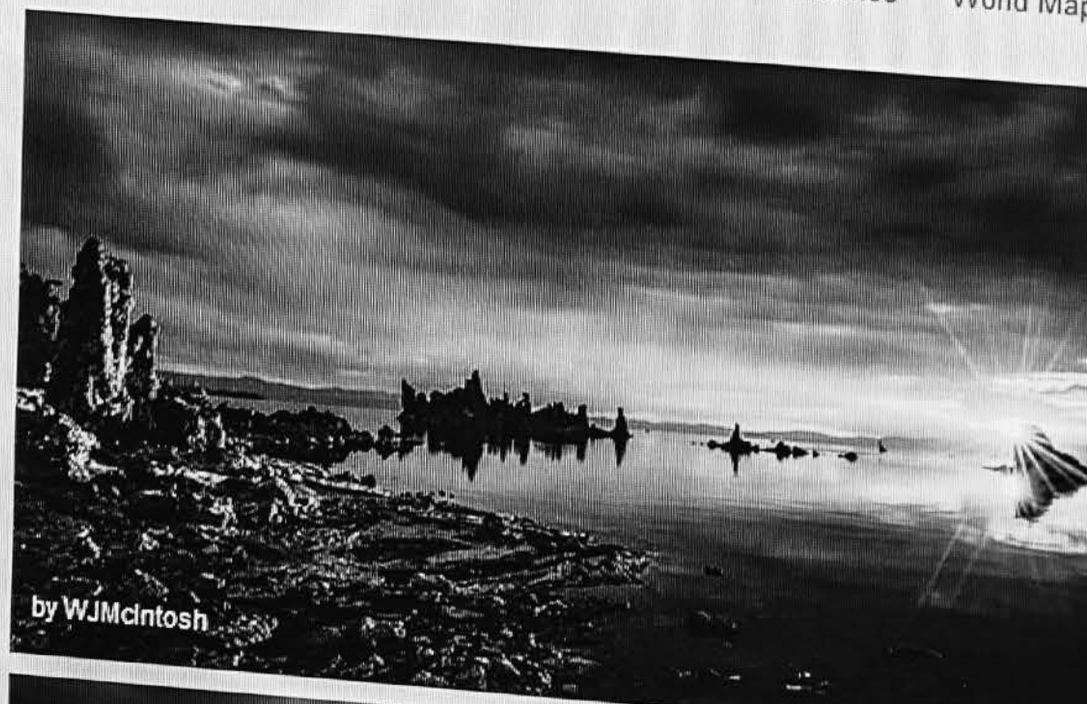

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25 Years of Innovation:

Personal Communications

by SooIn Yoon

1992

First SMS – sent over Vodafone GSM network in the UK. The text was...

1996

Hotmail launched – first free web-based e-mail provider

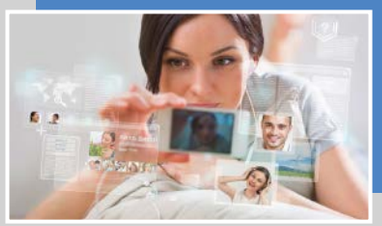
Hotmail®

1996-97

ICQ/AOL Instant Messenger launched

2003-06

Myspace, Facebook, YouTube, Twitter – the rise/emergence of social networking



2007

The 1st generation iPhone is released after years of rumors and speculation

2010

WhatsApp launched, FaceTime launched

2016

Smartphone market reaches saturation in developed countries

Personal Communications

In this retrospective article, SooIn Yoon looks at inventions from the last 25 years – from email to social networks and mobile phones – which have expanded our personal communications channels and changed the way we connect with each other today.

Over the last 25 years, we have seen a revolution in the way we communicate in our everyday lives. Long gone are the days of carrier pigeons and Morse code – okay, we're not that old. But from the first SMS sent in 1992, to over 20 billion text messages being sent every day today (give or take a few million), there have been enormous changes in how we connect. Personal communication has become more accessible and convenient, and new technology has enabled individuals to communicate with one another on a global scale. We've moved from physical, fixed platforms to digital, mobile technologies like texting, social networking, and over-the-top messaging and video, and the world has become smaller as our messages travel farther.

Advancements in how we communicate are not over, but let's take a look back in time to see where we've come so far.

90s: Email & Messaging

In the 1990s, we saw a shift in personal communications from mail and fixed voice lines to digital methods of communicating in email and mobile texting. The first free web-based e-mail provider, Hotmail, launched in 1996, allowing individuals to have their own accounts and send digital messages to anyone around the world. The limit for free storage at the time was 2MB and by early 1999, Hotmail had over 30 million active users worldwide. Email was a great way to send a letter in an instant what one used to send by post. Alongside email platforms, many instant messaging platforms such as ICQ (1996) and AOL Instant Messenger (1997) launched in this decade, allowing users to add friends to their "Buddy List" [i] and communicate digitally in real-time.

Personal communications also became more mobile as 2G connectivity was introduced in 1991, enabling data services for mobile. Around this time, mobile phones also became more accessible. Handsets were lighter, more portable, and most importantly, cheaper for the average consumer. The first mobile text message or SMS (Short Message Service) was sent in 1992 over the Vodafone GSM network in the UK with the message: "Merry Christmas" [ii]. As more consumers adopted mobile phones, SMS messaging became increasingly popular. While mobile phones and text messages exploded in popularity, other new communications devices such as AT&T's VideoPhone 2500, which enabled color video communication on a small LCD screen through phone lines, saw little commercial success. Although AT&T discontinued the product after just 3 years due to low sales (its retail price of $1,500 might have had something to do with it), the product was viewed as a technical success and was a sign of what communication might look like in the future.

00s: Smart Devices & Social Networking

At the turn of the century, we saw the rise of "smart" devices and social networking platforms. Devices improved in design, from color LCD screens to thinner form factors – the sleek Motorola Razr sold 130M units [iii] and was the best-selling flip phone in history, but it was the reimagining of their purpose and role in our lives that had the biggest impact on personal communications. The launch of the 1st generation iPhone in 2007 revolutionized the idea of a mobile phone as the ultimate communication tool. We could talk, text, and download a variety of applications that encouraged sharing, messaging, and expanding our network.

Online communities such as Myspace (2003), Facebook (2004), and Twitter (2006) launched in this decade as spaces for people to gather and communicate. These sites became popular platforms where one could share thoughts with friends, organize events, and participate in digital communities. Within these social networks, personal communication was not just limited to exchanges with one person, but expanded to broader interactions with groups of friends or an audience of strangers. As individuals around the world had increasing access to smart devices and joined these online communities, this type of communication enabled the spread of ideas between borders, triggering global movements that would continue into the next decade.

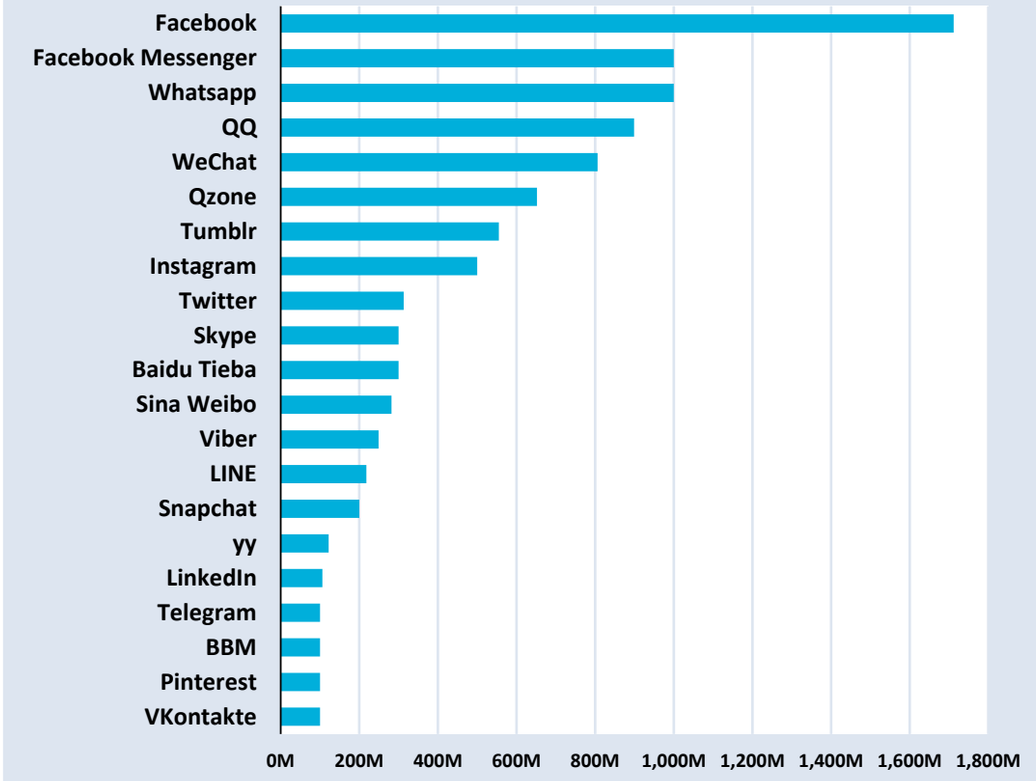
In addition to social networks, communication on a global scale also became more accessible through new voice, chat, and video software that enabled communication over the internet, such as Skype (2003). On these platforms, we could call, message, and eventually even see others for a much more affordable price than what traditional mobile providers offered. This trend continued into the next decade with more mobile applications that enabled data-based communication on the go.

10s: OTT Communication & New Social Networks

In the last few years, we have seen a significant amount of personal communication shift over to apps that send messages over the Internet. Apps such as WhatsApp, FaceTime, and Line have grown in popularity as better data and WiFi connectivity has spread throughout the world. WhatsApp, launched in 2010, was by February 2016 the most popular messaging app with 1 billion users worldwide [iv]. These over the top (OTT) messaging apps incorporate emojis, GIFs, photo and video sharing, and other add-ons to create a full-feature and enjoyable messaging experience. Communicating through photos and videos has become more popular and easier using data, as seen by the rise of new social platforms like Snapchat (2011) and Instagram (2010, acquired by Facebook in 2012).

These new OTT and social platforms have also grown in popularity in many developing nations as countries have skipped older connectivity technologies and enabled more advanced wireless technologies. In addition, mobile phone and smartphone penetration globally has reached saturation, meaning many people around the world are able to participate in this online community. This rapid adoption of smartphones over the last few decades has been a critical driving factor in enabling faster and more accessible communication with anyone around the world. As more people have joined the online community and engaged with others, we have seen the power of these platforms and connectivity to lead to revolutions, protests, and social change.

Active Users of Famous Social Network Sites Worldwide, as of September 2016[v]



Future: Next-gen Communications

In the last 25 years, the different platforms and methods we use to communicate have rapidly advanced. We are now more globally connected than ever before, and with the introduction of 5G connectivity and new devices over the next decades, our ways of communicating will continue to change. Maybe we will only speak in emojis. Maybe Alexa or Google Assistant will write messages to our friends for us. Maybe we'll reject everything and go back to good old fixed line rotary dial phones (seems unlikely). But one thing seems certain – we will not stop finding new ways to communicate and connect with one another. <>

Notes:

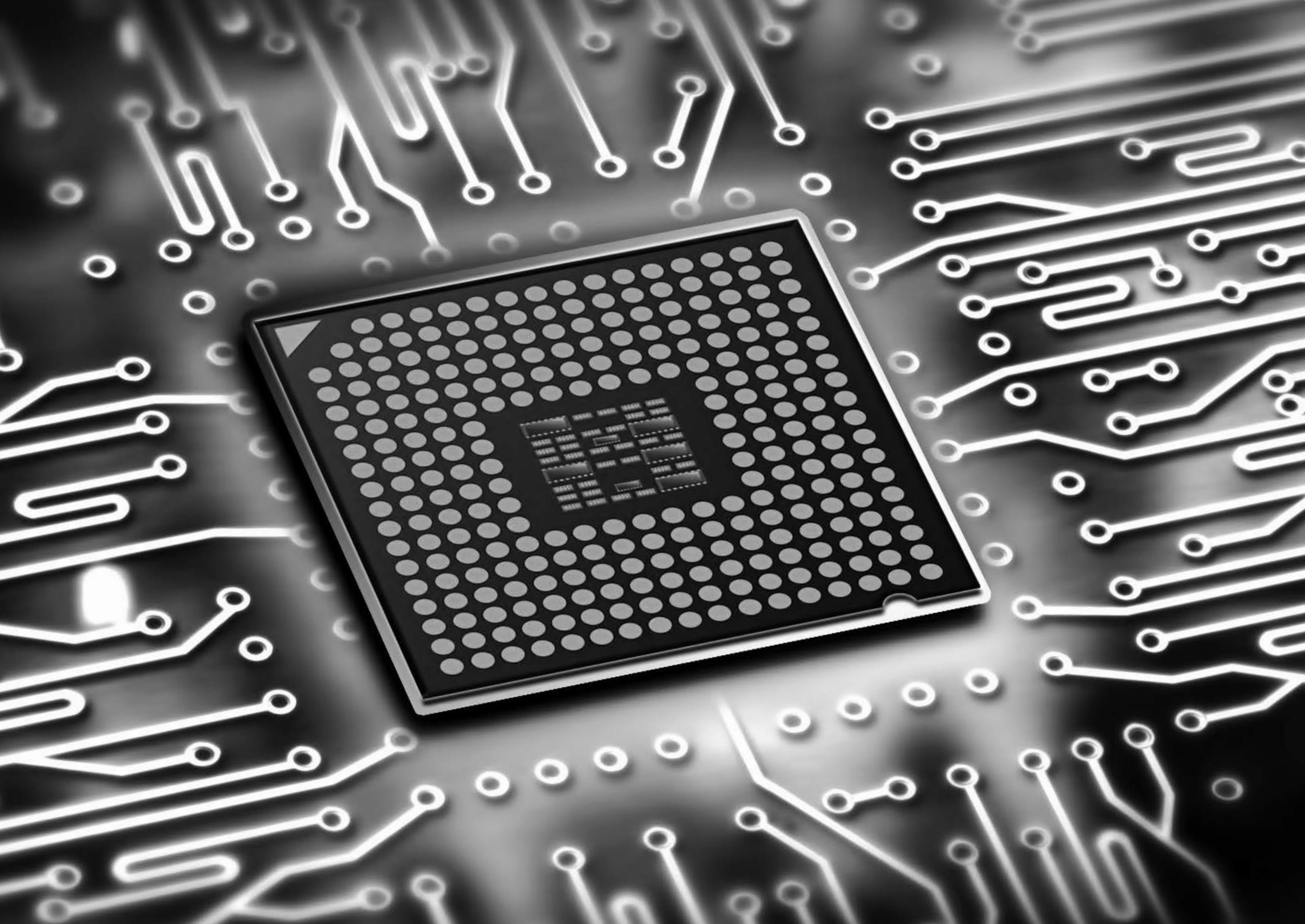
[i] Engel, KeriLynn. “The Rise and Fall of Instant Messengers”, WhoIsHostingThis.com

[ii] Gayomali, Chris. “The text message turns 20: A brief history of SMS”, TheWeek.com, December 2012.

[iii] “Hello Moto? Motorola denies return of iconic Razr flip phone”, The Telegraph, June 2016.

[iv] “Number of monthly active WhatsApp users worldwide from April 2013 to February 2016 (in millions)”. Statista.

[v] “Most famous social network sites 2016, by active users”, Statista, September 2016.



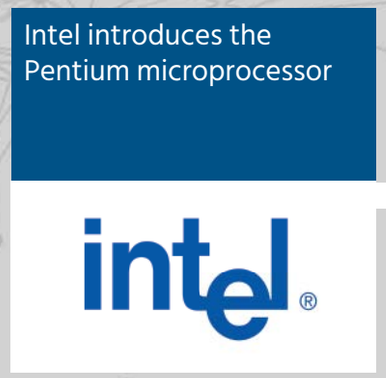
25 Years of Innovation:

Computing

by Morgan Pare

1993

Intel introduces the Pentium microprocessor



2003

AMD launches the first 64-bit processor for the PC market

1995

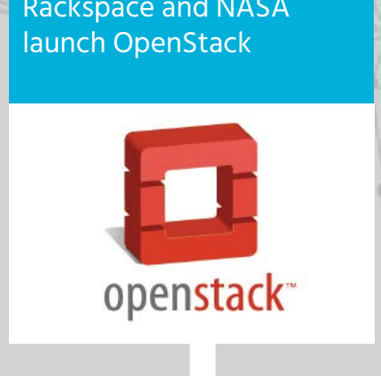
Microsoft launches Windows 95

2006

Amazon launches Amazon Web Services

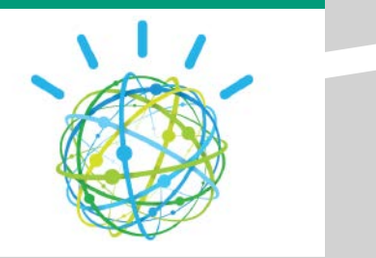
2010

Rackspace and NASA launch OpenStack



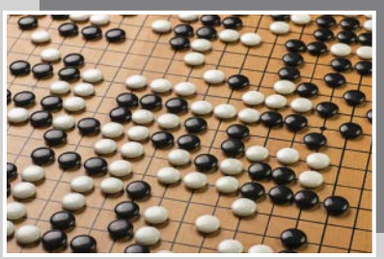
2011

IBM's Watson wins Jeopardy!



2016

Google DeepMind's AlphaGo beats Go! Champion Lee Seedol



Computing

In this retrospective article, Morgan Pare charts the inventions and partnerships of the computing industry over the last 25 years. What did it take to get computers into our homes, then into our pockets, and then to the "cloud"? Where will developments in artificial intelligence and machine learning take us to next?

In the past 25 years, computing has done its best to deliver on the promises highlighted by Bill Gates when he remarked that "Never before in history has innovation offered promise of so much, to so many in so short a time." Nearly everyone would have to agree with him when it comes to computing. In this article we explore the main advancements that brought us to where we are today and to help us along the way, I have scoured Spotify for the best songs of 1991 to remind us just how far we've come.

Cooperation *(Everything I Do, I Do It For You)*

If we were to hop into a time machine and set course for 1991, we would land right in the middle of a blossoming romance that has shaped the last 25 years of personal computing history – the software-hardware marriage of Windows and Intel. The two firms had been brought together 10 years earlier through the launch of its IBM PC and the 1990s was a great decade for both of them.

Microsoft's commercial success with the Windows OS began with Windows 3.0 in 1990. Windows 95 debuted the hallmark Start Menu and now infamous Internet Explorer which was followed up in the 2010s with the excellent *XP*, the better-forgotten *Vista*, the redeeming *7*, start-button-less *8* and Windows-as-a-service *10*.

For Intel, 1991 was the year in which it launched the "Intel Inside" marketing campaign. Intel achieved further brand differentiation in 1993 with the introduction of the Pentium microprocessor. Whilst Pentium brand proved to be a great a marketing success, some techies were initially upset by the absence of numbers (think HAL 9000 or R2D2!). That clearly didn't hold sales back, and by 2015, Intel's products featured in over 80% of PCs shipped worldwide [i].

Both firms benefitted greatly from the Internet-fueled demand for PCs in the late 1990s: the Wintel partnership provided both consumers and businesses with a fast, stable and intuitive interface with which to harness the major productivity gains that the internet offered.

However, neither firm did as well in the later wave of mobile computing devices, such as smartphones and tablets. Here, a hot new couple has emerged - ARM and Android. Android's OS powers 87% of the world's smartphones [ii], and ARM's chip designs feature in a whopping 99% of the world's smartphones and tablets combined [iii].

Methods *(Things that make you go Hmmm...)*

While less visible than the advances in personal computing, the evolution of back-office servers has been no less remarkable. The rise of the PC and Internet over the last 25 years has seen firms move from centralized mainframes, to distributed client-server architectures, and on to the current paradigm of virtual servers and cloud computing.

The availability of general purpose PCs in the 1990s, combined with the ability to interconnect them over local area networks opened the door to flexible client-server architectures. Far more affordable than monolithic mainframes, the client-server approach was widely adopted by smaller firms that didn't require the high-volume transaction capabilities of mainframe and couldn't afford their high price tag. File servers replaced 'Sneakernet' and commercial off-the-shelf software sales boomed.

The next wave of change came in the 2000s with the emergence of 'cloud computing'. Rather than dedicate servers to particular applications and have them stand idle when not needed, cloud computing uses virtual machines that can share server hardware. These virtual machines are created in software and can thus be set up and torn down very quickly, without the need to order, rack and configure physical machines. This ability to dynamically assign computing power is far more efficient for applications with demand that changes by time of day, or day of month (think: "billing cycle"). It also provided the capability to have multi-tenanted platforms, which has enabled new business models that charge for computing power – Infrastructure as a Service – on a usage basis.

The economics, flexibility and ease of consumption of virtualization has led to rapid adoption throughout the IT industry. Many firms have chosen to use multi-tenanted, public cloud services such as Amazon AWS and Microsoft Azure. Others have built their own private clouds, and some have a hybrid of both. It's interesting to note that Amazon's cloud efforts were initially a response to scaling its private computing needs; however, by sharing the platform with tenants it has reaped enormous scale (and unit cost) benefits for its retail business.

Virtualization has been key to scaling some of the largest and best-known online services. Another important advance has been in the field of distributed computing. Distributed computing divides large tasks into subtasks and distributes these for execution across many servers which massively aids speed and efficiency. Importantly, these approaches are designed to work with large clusters of inexpensive, commodity servers which is the exact opposite of the mainframe world. This parallel processing approach has enabled firms to cost-effectively process huge volumes of data, allowing web giants such as Google and Facebook to scale and fuel their businesses.

In the software market, cloud computing has also spawned the concept of Software as a Service (SaaS). In the SaaS model, applications are hosted online and accessed using a web browser as a thin client. Examples include Google Docs (on which this article is being typed) and Microsoft's O365. Hosting software in this way enables new features and bug fixes to be applied centrally, much like mainframe software. It promises lower support costs by removing the need to distribute, install and maintain local copies on PCs. It also provides an opportunity for the vendor to charge on a recurring basis and is a good defense against piracy.

Finally, with greater computation fire power, there has been increasing focus on artificial intelligence (AI) and machine learning. Both awe-inspiring and slightly terrifying, these technologies have stirred controversial debate in the late 2000s and into the 2010s, mainly surround safeguarding against future machine-mishaps and defining the increasing role computing plays in our lives. IBM's Watson is most famous for its triumph on Jeopardy in 2011. Today, Watson is helping revolutionize the healthcare industry; it can process vast repositories of medical data and help doctors to reach a correct diagnosis and prescribe for even the rarest symptoms. Last year, Google's Deepmind used a machine that learned through playing itself to beat Go! champion, Lee Seedol, and brought into stark focus the growing resemblance of computers to humans.

Whilst the means by which computers have been employed over the past 25 years has varied massively, it is clear that each innovation brings a world of opportunity, functionality, and fascination.

Moore's Law *(Should I Stay or Should I Go?)*

Moore's Law captures an observation by Intel Co-founder Geoff Moore, that the number of transistors that can be put on a microchip doubles every year or so. Since 1965 [iv], this exponential increase in computational power has been a driving force behind advances in the electronics and high-tech industries. The ability to process more information, more quickly, and at lower cost than was possible the year before, has fueled competition and new entrants in many sectors. It also accounts for the fact that your new smartphone is likely to have vastly more power than a PC you bought in the previous decade.

Given the importance of Moore's Law to the industry, advances in microprocessors are closely tracked and much effort is spent on finding new paths to higher performance. Chipmakers have been nearing atomic limits for some time and it will soon be physically impossible to continue shrinking silicon transistors as well as fund the R&D required to do so.

However, industry observers will tell you that the law has always had its sceptics, as Peter Lee (VP at Microsoft Research) jibes, "The number of people predicting the death of Moore's law doubles every two years."

The possibility of an end to Moore's law presents an inflexion point and incentivizes researchers to experiment with other exotic methods in order to extend the rise in computing power. Such methods include exploring different materials beyond silicon; others take an even higher level approach, questioning the very nature of current computing methods through harnessing quantum mechanics or emulating biological brain functions.

The Future *(Get Ready For This)*

Questions still surround the future of computing. As the cloud continues to drive down costs and revolutionize the way that enterprises and consumers alike approach computing, will expensive hardware-ownership become extinct? Will other relationships emerge to define this era – perhaps even the very relationship between Man and Machine? And finally, will a new champion step up to honor Moore's law – be it similar or a different beast entirely?

Despite the lingering questions, when looking back at the pace of innovation in computing over the last 25 years and the promising trends that are emerging, it is clear that there is reason to be optimistic and excited about computing's future. <>

For your Playlist:

- "Everything I Do, I Do It For You" Bryan Adams, Albums: *Robin Hood: Prince of Thieves* (soundtrack) and *Waking Up the Neighbours* (June 1991).
- "Things That Make You Go Hmmm…" C+C Music Factory, Album: *Gonna Make You Sweat* (June 1991).
- "Should I Stay or Should I Go" The Clash, Album: *Combat Rock* (June 1982). Rereleased: *Rush* (1991)
- "Get Ready for This" 2 Unlimited, Album: *Get Ready!* (September 1991).

Notes:

[i] King, Ian. Bloomberg: "Intel Forecast Shows Rising Server Demand, PC Share Gains". July 2015.

[ii] IDC: "Smartphone OS Market Share, 2016 Q3". Q3 2016.

[iii] Vance, Ashlee. Bloomberg: "ARM Designs One of the World's Most-Used Products. So Where's the Money?" February 2014.

[iv] Simonite, Tom. MIT Technology Review: "Moore's Law Is Dead. Now What?" May 2016.

25 Years of Innovation:

Internet Access

by Michael Dargue

Mid '90s

Early cable modems released by Motorola, LanCity and others

1991

AOL launches an Internet access service for Windows PCs in the US with a flat-rate monthly fee

1998

The ITU approves the V90 standard for 56kbps dial-up modems

2000

The first person in the UK gets broadband installed at home

2005

In the US, Verizon launches FiOS, bundling broadband, phone and TV over an FTTH network; In the UK, Ofcom reports that there are more broadband subscribers than dial-up

2010

Commercial launch of BT Infinity, an FTTC broadband service offering up to 76Mbps

2012

Virgin Media offers 120Mbps cable broadband in the UK

2013

BT announces a trial of G.fast technology, capable of delivering 100s of Mbps over copper

Internet Access

In this retrospective article, Michael Dargue reminds us of what it was like when there was only dial-up in the UK. As the internet grew and applications became more sophisticated and rich, so have expectations of what we can retrieve online and how quickly. See how internet access picked up speed and capacity over the last 25 years.

The Dial-Up Years

It may be hard to believe, but 25 years ago there was no broadband. To access the web in the 90s, you either needed a dial-up modem or a dedicated leased line. Leased lines were unaffordable for home use. So dial-up it was.

I'll be honest... dial-up access wasn't great. The speed really sucked and it tied up your home phone line so you couldn't make or receive calls while connected. Maybe that doesn't sound too bad nowadays, but back then few people had mobiles and residential lines were a lot more popular than they are now. Also – in the UK at least – the call charges were a killer. It took the UK several years to move away from per-minute pricing for dial-up access.

Of all the problems with dial-up, the speed was the worst. Measured in 10s of kbps it was a literally a thousand times slower than current broadband services. Users had to wait patiently for web pages to reveal themselves and if you wanted to download a file it could take several minutes to arrive. The speeds were so bad that it was common practice back then for websites to add helpful notes indicating how long each file would take to download.

It's sad to say, but I can recall when I upgraded to a US Robotics 56k modem. Even worse, I still remember the noise the modem made when connecting (click here if you want to reminisce) [i]. But these were the days when you really had to wait for each web page to load. And a shiny new modem that would cut your wait time in half was not to be sniffed at.

However, my gains in speed were only temporary. Throughout the 90s, websites were continuously becoming more sophisticated and richer in content. Sadly, this also meant longer times to load pages and browse the web. For an Internet user back then, it was as if the pace of the web was always one step ahead of you. The number of wasted seconds spent downloading unwanted banner ads was truly painful.

Enter Broadband

This all changed in the year 2000. At the time, I was working for an ISP and was lucky to be one of the first in the UK to get a home broadband connection. Straight away, it was clear there could be no going back. The experience was in a completely different league to dial-up. No longer limited to 10s of kbps, I now had 2Mbps! It was like getting off a bicycle and stepping into a Ferrari. I could now zoom about the web at speed.

The engineering breakthrough in DSL broadband was to carry the data in the unused frequencies, alongside the "narrowband" audio voice call. With the right filters in place, both services could then operate in parallel. Cable broadband employed a similar technique on its hybrid fiber-coax network, carving out spectrum to carry data alongside TV.

The change was so great that websites like Heavy.com launched specifically to serve broadband users with rich content. These early sites presaged the spectacular rise of video entertainment on the Internet. Today, video makes up the vast majority of the net's traffic, driven by YouTube, Netflix and countless others.

Aside from the speed kick – and perhaps even more revolutionary – was the fact that broadband access was "always on". With dial-up, users always had an eye on the clock. With broadband, that was no longer a concern. You could leave your PC connected to the Internet 24x7 if you wanted to. No one was counting the minutes any more.

Not only did this mean people spent more time online, it also increased the range of potential applications. With an always on connection, it became possible to run your own webserver at home if you wanted to. It also provided a platform for peer-to-peer networking, allowing P2P apps like Skype and Spotify to flourish, alongside Napster and many other file sharing programs.

Speed Wars

Ever since broadband first became available, there has been a fixation on speed. Over the next 10 years, my 2Mbps connection went to "up to 8Mbps" and then to "up to 24Mbps" – impressive advances in both technology and marketing! Fortunately, I lived not too far from the local BT exchange and got about 16Mbps or so.

Others were not so lucky. As DSL performance depends on the length and quality of the connection to the exchange, consumers found they were in a postcode lottery when it came to broadband speed. Homes that were too far away, or connected by aluminium rather than copper, didn't make the grade.

For those fortunate to have a choice of network operators, speed became a key weapon in the battle for market share between cable operators (MSOs) and telcos. Successive generations of cable broadband and DSL technologies have edged speeds ever upwards as providers have sought to keep pace with one another.

However, by the late 00s, the telcos had squeezed out pretty much the last drop of performance from the copper lines from the exchange. Going faster was going to require a new approach, a next generation access network.

The Next Generation

To overcome the distance limitations of DSL, telcos had two options available The first, was to significantly shorten the length of the copper lines, by moving the DSL equipment from the exchange buildings to street cabinets much closer to the customers ("Fiber to the Cabinet", FTTC). The second was to abandon copper altogether and move to fiber ("Fiber to the Home", FTTH).

Cable operators didn't face the same distance challenges as their telco cousins. Having digitized their cable networks, they've been able to increase speeds largely through spectrum reallocation and new modulation schemes. Cablecos also have the option of "node splitting" – sharing the available capacity between fewer end customers – as demand grows.

Using these techniques has propelled cable broadband beyond 100Mbps and even 1Gbps is now possible – residential speeds that no one would have dreamt of 25 years ago. For telcos, current FTTC technology tops out at about 80 – 100Mbps, so keeping up with cable now requires a new round of network investment.

A Fiber Future

Like many in the UK, I've made the switch from regular DSL to "fiber broadband" (FTTC). My broadband is now "up to 52Mbps" and, to be honest, it meets our current needs. The question is for how much longer.

Ever since the early days of the web, consumers have constantly wanted better network performance. The emergence of online applications such as video calling, watching catch-up TV and real-time online gaming have all increased the need for speed. Who knows what we'll be using our broadband connection for next. Will it be watching ultra-high definition TV on Netflix, or immersive VR gaming?

It's clear that bandwidth needs will grow, but predicting exactly when the existing networks will run out of puff is harder.

Ultimately full fiber is going to be needed, but the big question is when. Given the time and cost of building out large scale FTTH networks, when should operators start the migration and how fast should they go? Should they sweat the copper network further (e.g. using G.fast to go to ~300Mbps) or move directly to a full fiber network?

Given the importance of the Internet to our connected lives, the answer to these questions matter not just to consumers at a personal level, but to society and the economy at large. <>

Notes:

[i] "Remember 56k modems?" https://youtu.be/p8XKhCfsTts - Uploaded by Masoolsa, YouTube, September 2009.

Actions Help

Reply Reply to All

Inbox

25 Years of Innovation:

Business Communications

by Hassan Malik

1995

Vocaltec launches the first VoIP application

1997

Microsoft includes Outlook in its Office 97 release; The first IP PBX is introduced, marking the start of Unified Communications

1999

RIM launches the Blackberry 850, mobilizing business executives

2003

LinkedIn launches

2007

Google launches Google Docs

2011

Microsoft buys Skype and launches Office 365

2013

#Slack launches

Business Communications

In this retrospective article, Hassan Malik takes us back to the time of paper memos and faxes to today's office with unified communications and collaboration solutions. From email to instant messaging and video conferencing, over the past 25 years, business communications have become faster, more instantaneous, cheaper, richer.

Do you remember sending a memo around the office in an envelope sealed with a string, booking a long distance call with a co-worker, or catching up on the latest news or TV programme around the office water cooler? If all that seems a distant memory, or you don't know what I'm going on about, I don't blame you. These days, there are so many options to instantly communicate in an office, that it's hard to imagine (or remember) what it used to be like just 25 years ago. Business communications have become much more varied, collaborative, and instantaneous since then.

Digitizing Messages

Twenty-five years ago, the choice of office communication methods was simple: phone, fax, and post. Despite email and networking technologies existing before the 90s, adoption within an office was slow at first. Businesses adoption of new communications tools often happens slower than expected: investments must be prioritized against other needs for finance, IT teams have finite bandwidth, and there's no accounting for user preferences.

In the 90s, paper dominated our office lives. Some offices had busy mailrooms, in others staff collected their mail from a personal "pigeon hole". There were memos, inter-office mail, and all kinds of delivery services. The most common method to share important documents between offices quickly was by fax (short for "facsimile"), which used the telephone network to send documents. The alternatives were post (a.k.a. "snail mail") or expensive courier, e.g. Fed-Ex. In addition to speed, a signed document sent by fax was treated as a legitimate copy of the original. It took a long time for businesses to trust and accept email in the same way.

In the early 90s, workplace IT was fragmented: the experience was poor and clunky with competing platforms such as Lotus Notes and Microsoft Exchange that didn't play nicely together. It wasn't until the mid-to-late 90s, that common network protocols and standards enabled the business community to truly enter the digital age. The price of computing hardware dropped, and PCs and Microsoft applications, notably Outlook (launched in 1997 with Office 97), dominated the consumer and enterprise market. Email became ubiquitous – finally, the business community had an effective alternative to phone and fax.

Unifying Communications

During the early 90s, everyone had a desk phone linked to the office's enterprise telephone switching system - the PBX (Private Branch Exchange). Back then, it was likely a simple voice-based telephony service, even though more advanced features such as conferencing existed at that time. Video conferencing was also possible, but costly, and also lacked good quality. Conference calls were often made in meeting rooms with special equipment, adding more cost and limiting flexibility.

In 1995, Vocaltec launched the first VoIP (Voice-over-Internet-Protocol) application [i]. This kick-started the race to reduce the cost of enterprise communication by using the internet. In 1997, the first Internet Protocol (IP) PBX [ii] was introduced. This, to me, was the point at which the use of our much-loved Unified Communications (UC) was enabled.

In the early 00s, with the introduction of second-generation VoIP applications, such as Skype (launched in 2003), IP telephony and UC started gaining traction. A number of start-ups launched and were later acquired by the likes of Cisco, Microsoft, and Nortel. PBX vendors such as Avaya saw an opportunity in UC but one which cannibalised their traditional PBX product revenues. By 2006/07, Microsoft and IBM had promising UC solutions that could provide the necessary communication applications, such as Instant Messaging (IM), with a call control capability linked to an enterprise's PBX. These UC solutions gathered significant momentum, driving three-digit growth figures in 2008-09 [iii].

These events marked the start of the end for the traditional PBX. However, although the sale of new PBXs declined, enterprises were not ready to switch off their existing PBXs until these assets had fully depreciated, putting a downward pressure on UC adoption. This was probably for the best as early in the 2010s, Unified Communication and Collaboration (UC&C) tools faced the same challenges as email did in early days – lack of ubiquity. Solutions offered by UC&C vendors were disjointed and poorly patched together, offering clunky performance and poor experience. Like email before it, businesses on a single vendor platform could not talk to businesses using a UC&C solution by a different vendor.

In the race to develop the most comprehensive UC solution, Cisco and Microsoft took the lead. Cisco had its telephony heritage as its strength whereas Microsoft capitalised on its strong software integration into the enterprise ecosystem. Cost and productivity benefits demonstrated by these UC&C solutions meant that businesses have gone through another change in communication mechanisms.

In more recent years we have seen how collaboration platforms such as Microsoft SharePoint (launched in 2011), Google Drive (2012) and more recently Slack (2013), are changing how we store and share knowledge. Instead of sharing documents using network drives or sending large email attachments, the trend to store material on a collaboration platform is becoming the norm. There have been further improvements with web-based conferencing solutions. Notably, since Microsoft's purchase of Skype in 2011, Microsoft has incorporated its well-known video conferencing features into its IM platform. With these UC&C solutions, telephony, email, conferencing, instant messaging, storage, and multi-user document editing have all come together in one platform. However, business communications didn't just change in the office building. Over this same period, the workplace became mobile.

Mobilizing the Workforce

In 1999, a little known Canadian start-up called RIM launched a game changing product called the Blackberry 850 [iv]. This simple device offered a black and white screen with no more than 8 lines of text display. Connected to the corporate network, it offered essential capabilities such as sending and receiving messages, emails, calendar, and address book integration with a QWERTY keyboard. In 2003, Blackberry launched the 7210 with a colour display and the capability to not just send and receive email on the go, but also the ability to open PDF, PowerPoint and Excel documents, making itself indispensable within the business environment.

Blackberry not only made access to email better, but also changed our attitudes towards business communications and staying connected. Senior executives started carrying work in their pockets while on holiday and suddenly there was an expectation that response to an email will be almost immediate.

Then Apple launched the first iPhone in 2007 and propelled smartphones into the mainstream. Now, everyone was getting a smartphone whether or a company provided them or not. Staff could connect to the company's enterprise networks with WiFi or mobile data. Soon it was not only smartphones, but also tablets and other devices. Collectively, we started calling this trend Bring-Your-Own-Device (BYOD). At first, corporate IT departments resisted the BYOD trend with fears of security breaches and mishandling of corporate data but those precautions didn't stop employees from using their devices. Once the corporate directory was on a personal device, employees had the ability to use consumer applications, such as WhatsApp, to stay connected with their co-workers, and even customers. Now that every employee had a smartphone, a company's workforce was connected everywhere and anywhere – work and personal lives became more interwoven.

Building Social Business Networks

Like consumer devices, social media is also enmeshed in today's business communications – starting with the business networking tool LinkedIn (launched in 2003), and including social networks, news networks, and image sharing applications such as Facebook (2004), Twitter (2006), and Instagram (2010). More recently, Slack, a cloud-based collaboration tool has gained traction with businesses and consumers alike. Not only are these new platforms used to communicate with co-workers outside the office but also to reach out to customers, partner organizations, and industry associations, as an effective way of sharing and exchanging knowledge. So it was no surprise that Facebook showed its commitment to enterprise, with the launch of its enterprise collaboration tool, Workplace, in late 2016. With social media, business communications has moved beyond office walls and out into the wider world.

Social media hasn't eliminated the need for phone, email, and post for sharing official news and documentation, but it has enhanced what we do in the office. Just today, I have sent several emails, used Skype conferencing four times, caught up with my friends on WhatsApp, and collaborated with my colleagues via Slack whilst working on documents on SharePoint. Looking back at the past two decades and considering that we started with paper memos and faxes, we've come a long way. How will advancements in video, virtual reality, augmented reality, 3D printing, and robotics further enhance how we communicate in the office? I'm excited to see what's next. <>

Notes:

[i] BeBusinessEd.com: "The History of VoIP"

[ii] BeBusinessEd.com: "History of PBX"

[iii] Parker, Marty. Unified Communications Strategies: "A Short History of UC". July 2009.

[iv] ZDNet.com: "A history of Blackberry in Nine Iconic Handsets and (One Meh Tablet)". January 2013.

25 Years of Innovation:

Advertising

by Rahul Keerthi

1993

First online images appear, including non-interactive advertising

1994

First interactive banner ad debuts, taking web advertising to the next level

AT&T

Late '90s

E-commerce and entertainment websites proliferate; Search Engine Optimisation (SEO) industry begins to take shape

1996

Google is incorporated by Larry Page and Sergey Brin and run out of a friend's garage

Google

2004

Facebook is launched by Harvard student Mark Zuckerberg and friends

2006

Twitter founded by Jack Dorsey and several employees at podcasting company Odeo

2009

Facebook enables ad placement based on user demographics and location

Advertising

In this retrospective article, Rahul Keerthi takes us through the past 25 years of advertising. As the industry moved to digital ads and businesses turned to Google and social media, we look at what has changed – and what hasn't – in the battle to reach consumers.

Past is Prologue

Advertising – seen and unsighted – surrounds each of us every day, entreating the subconscious to consider a product, an idea, or lifestyles within our reach. Advertising has not changed its purpose in the Internet era: it continues to connect consumers to products and services through their kaleidoscope of needs and desires. The best ad ultimately is one that firmly piques its audience's interest – its relevance to them matched only by its resonance.

Over the last 25 years, advertising has been a standard-bearer in the digital revolution. Because of its success, advertising-funded traditional print media is facing its greatest ever challenge for survival. Almost every newspaper that had a print edition in the 1990s now has an online equivalent, though the Internet's greatest contribution to advertising is its disintermediation of mass media. Advertisers no longer rely solely on TV, radio and newspapers to reach the masses – they can now effectively sell their products through YouTubers, Apps, the Twitterati, and bloggers.

If you want to get to the gist of advertising's journey in the last 25 years, its story is the story of Google. Past is still prologue though, so let's start there.

Billboards of the Internet

Advertising has first and foremost been a creative industry. The early 1990s saw the development of publishing and graphics applications such as QuarkXPress, PageMaker, Publisher, Fauve Matisse, Lightworks, Adobe Photoshop and CorelDRAW. These gave designers the tools required to efficiently create graphics and layouts for print publishing, and increasingly, online publications.

Unsurprisingly, the first internet advertisements also appeared during this time: first as non-interactive images in 1993, then famously they became hyperlinked - the first banner ad, for AT&T, appeared on Wired magazine's digital sister publication, Hotwired, in 1994. In a quest to mimic their analogue brethren's revenue streams, publishers began offering ad space for a fixed time-period on their websites to companies for a fixed fee, not dissimilar to the way advertising on real-world billboards or hoardings worked.

Prior to this, Internet access was a paid subscription service like any other – Internet Service Providers (ISPs) like AOL offered access to web content as a feature of the product despite the fact that most of this content was neither created nor owned by them. With the introduction of online ads, these billboards of the information superhighway, publishers and content creators could now monetise their content. The going rate was good – Hotwired charged $30,000 (£20,000) for 3 months of ad space – but with 44% of visitors clicking on the ad (43.9% more than an advertiser would expect today!) the idea quickly caught on.

As the Internet grew and speeds increased in the late 1990s, e-commerce and entertainment sites proliferated, as did space for and revenues from advertising. The race for eyeballs was on. Pop-up ads, a common complaint of modern browsing, started appearing then, as did the tools to block them. This battle has continued to today, a game of one-upmanship that appears to have lost sight of what the relationship between advertising and consumers should be.

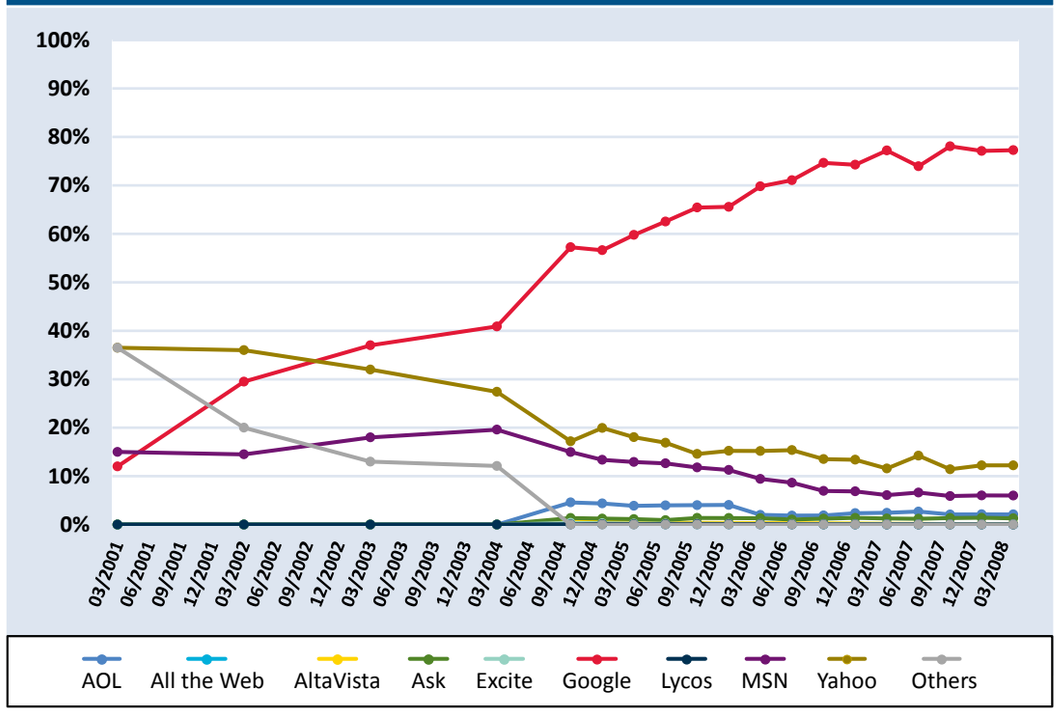
In the early 2000s, broadband speeds created the media-rich Web 2.0. Advertising, ever-diligently, took the initiative by using embedded audio and video, as well as more interactive advertising. Big brands began pouring money into elaborate digital campaigns and the quest for eyeballs became every advertiser's obsession and every agency's nightmare. This frenzy hit its peak in 2005 when Wiltshire student Alex Tew created a website to sell each pixel of a 1000-by-1000-pixel image to advertisers for $1 per pixel. This was the "Million Dollar Homepage [i]," and it made Alex a millionaire in 5 months [ii].

The Big Game Safari

This was a drop in the online advertising ocean, however. By then, a Palo Alto start-up called Google had a market capitalisation of $52B [iii], larger than the GDP of 52 countries at the time including Cuba, Uruguay and Luxembourg [iv]. Its revenues were over $6B in 2005, with 99% coming from its advertising products [v].

What had started out as yet another ambitious search engine, attempting to help people navigate the increasingly chaotic and disparate Internet, had quickly become the de facto gatekeeper to the information superhighway – and all the billboards on it.

Google Market Share vs. Other Search Engines, March 2001 to March 2008[vi]



David Ogilvy, often celebrated as the father of modern advertising, had several tenets of which one was, "Never stop testing, and your advertising will never stop improving." Testing was difficult in the print world. You ran focus groups, you tried to sense the zeitgeist, but once launched, a campaign had to be stuck with until the end.

The Internet, on the other hand, was both a laboratory and arena for advertisers. Advertising wisdom suggests you learn how lions feed by watching them in the wild, not in the zoo, and here they were presented with a big game safari park – the best of both worlds. Advertisers could experiment in the Internet lab and the Internet arena would immediately show what works and what didn't.

Where Google co-founders Eric Schmidt, Larry Page, and Sergey Brin struck gold was the realisation that the logic behind its relevant search results could also make ads more relevant to users and much more likely to lead to a click (its PageRank algorithm was based on the premise that more important websites are likely to receive more links from other websites). This logic took shape as Google's Quality Score, which valued not just how much was paid for an ad in an auction (as other search engines did), but also how relevant the ads were, judged continuously by how often they were preferred by searchers.

The Quality Score algorithm powered its two key products, Adwords (ads on search results pages) and Adsense (ads on third-party websites) – both runaway successes for the company to this day. Search Engine Optimisation (SEO) as an industry was born out of a need to maximise ROI from advertising products like these. The growing complexity and continual innovation of the algorithm is testament to how fundamental it still is to Google's business model– despite its massive diversification into other products, advertising still accounts for more than 90% of Google's revenues today.

Needs, Wants, Intentions, Identities

Google later acquired DoubleClick, a small New York Internet start-up, which pioneered the tracking of digital advertising campaign success in near real-time, allowing advertisers and agencies to shorten unsuccessful campaigns or redirect spend to more successful websites. It also enabled targeted advertising by making inferences about user interests by their characteristics. This was a new watershed – advertising was no longer just about what you needed, it could now be about what you might want based on what else you were interested in.

Facebook, like Google in the search engine world, came to dominate social media in the late 2000s. Their revenues today are primarily from advertising, and their unique proposition has been the ability to use the information you voluntarily offer them (e.g.

interests, locations, age) to offer advertisers a level of targeting not possible elsewhere: voluntary participation, flexible segmentation (e.g. Oreo lovers aged 35 to 49 in West London), hundreds of attributes, and accurate real-time measurement. Twitter, another social media maven, offers relative anonymity and gathers little data from users; it has unsurprisingly struggled to grow its advertising revenues relative to usage.

Gathering swathes of data for painting ad targets can be concerning – how much is too much? What else could they do with this data? Is it safe? Advocates for privacy and consumer rights have pushed back against this perceived intrusion into our lives, aiming to strike a fairer balance in an advertising economy where the prevailing wisdom is, "if you aren't paying for the product, then you are the product." However, it seems that people don't know how their data is used and even when made aware, often simply don't mind or care.

Bridging Worlds

The Internet, initially designed to be a mere digital Library of Alexandria, has transformed over time into an archipelago of digital tribes – a haven of individual expression and a home to diverse subgroups. In this new world, customers segment themselves on Facebook more effectively than a marketing strategist ever could; they articulate purchase intention on Google more clearly than any salesperson could hope for; they spread ideas on Twitter quicker than any branding guru might imagine.

While advertising is as much a part of our digital lives as it is our real-world ones, new technologies such as augmented reality and virtual reality will aim to bridge those two in surprising and useful ways. Despite all these advances in technology and relevance, advertising itself remains a creative practice – technology cannot (yet) write you good, resonant copy.

"If you have all the research, all the ground rules, all the directives, all the data… you've [still] got to close the door and write something — that is the moment of truth…" - David Ogilvy <>

Notes:

[i] The Million Dollar Homepage™

[ii] Richardson, Tim. "Pixel-flogging student makes a million." The Register, 16 Jan 2006.

[iii] Alphabet Inc. (GOOG). Historical Prices, Monthly, Dates: 19 Aug 2004-1 Dec 2005. Yahoo Finance.

[iv] GDP at market prices (constant 2010 US$), 1960-2005. The World Bank.

[v] Distribution of Google's revenues from 2001 to 2015 by source. Statista.

[vi] Pollock, Rufus. Search Engines Market Share. Last Updated: 11 Oct 2013. Datahub.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34s
04m31s
03m58s
13s
03s
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0,1632
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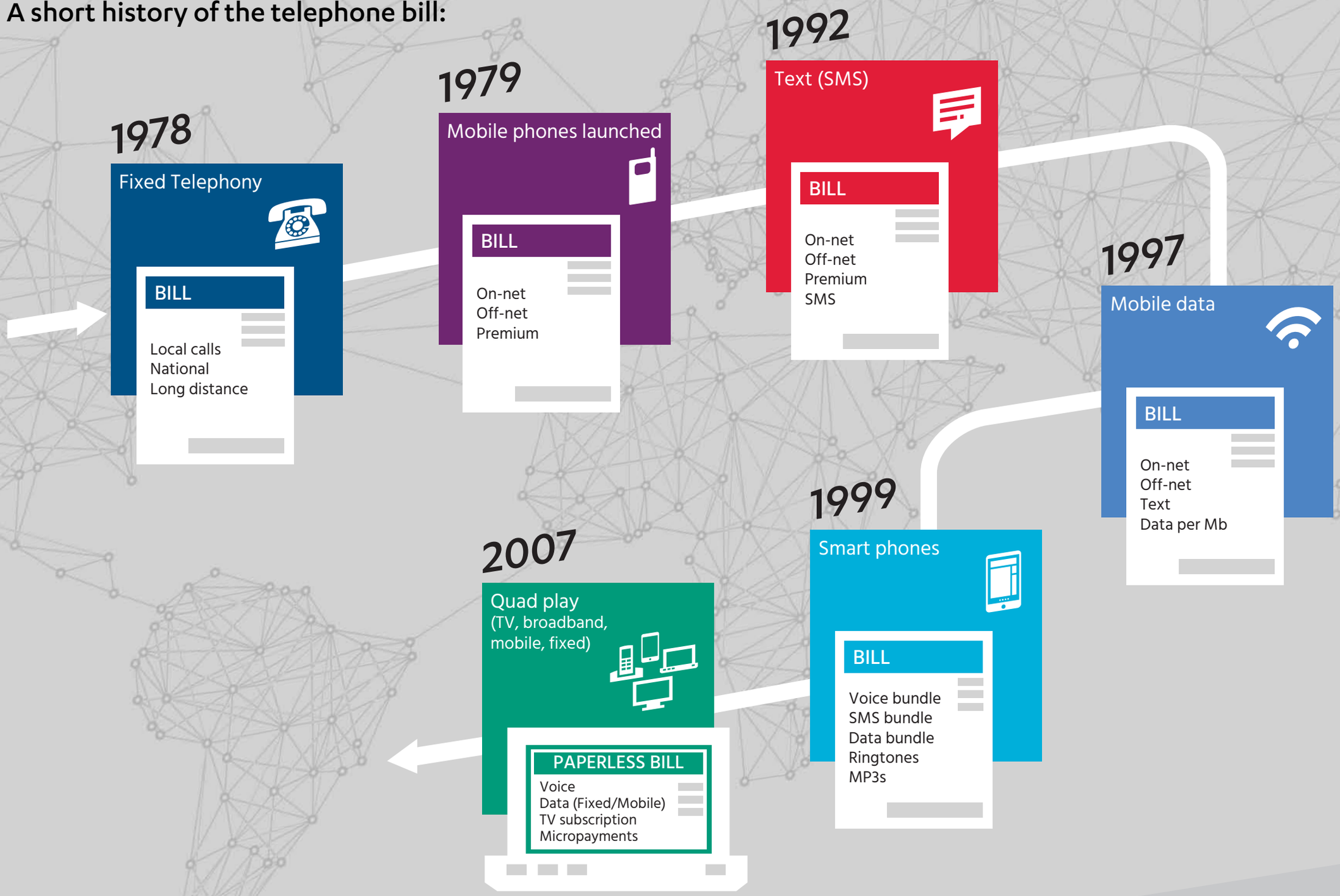
25 Years of Innovation:

Billing Systems

by Doug Melbourne

A short history of the telephone bill:



Billing Systems

In this retrospective article, Doug Melbourne takes us down memory lane to recount his early days of telecoms billing back in the 90s to the complexities of calculating today's bill. From pulse-based billing systems, to time-and-distance billing, to billing for quad-play bundling – who knew that a simple phone bill could be so tricky? Join us on his 25-year journey.

Have You Paid For That, Sonny? The Evolution of Telecoms Billing

I have been in the telecoms industry for thirty years. I went into telecom/broadcasting straight from college, two years after the first mobile phone was launched in 1984. They were huge, walkie-talkie styled objects owned by a small number of people and…you could make phone calls with them – if you were lucky – and strong enough to hold it to your ear for an hour.

Today, I can walk down a busy street having a conversation via my wireless Bluetooth® headset with someone on the International Space Station, whilst downloading music, watching the news, and playing "Angry Birds", all at the same time.

Obviously, if I did all these things at once while walking down a busy street, I would probably meet with a terrible accident. The battery life hasn't improved that much, either.

But I digress. For most of my career, I have worked in the field of BSS (Business Support Systems) and those parts of a telecoms infrastructure dealing with rating, billing, and collections. Since those early days, my chosen field (actually, it seemed to choose me) has changed dramatically.

When I first encountered telephony billing, most of it was based on charging you for the destination of the person you were calling, and how far away you were from there. There was a variable rate for peak and off-peak times. Oh – and some premium rate lines for your bookies, or the weather, or your horoscope. That was about it! When you made a phone call, a CDR (Call Detail Record) was created which contained all the information you needed to price that call. It was held on the switch until it was collected (once or twice a day) and then used to price the call according to your rating tables. At the end of the month, these rated call records would be added up and a bill would emerge. A customer's phone bill was also fairly straightforward: a simple total of the calls and some indication of what sort of calls they were. No complicated discounts, no special customer messages, no other services to be itemised.

In fact, in the early 90s, I worked on one project in Poland where they were still using pulses for measuring the value of the call. I had the dubious pleasure of converting their price list from "number of pulses that… pulsed during a call" to the more familiar time-and-distance based scenario. Not too bad you might think, but it wasn't so much the basic conversion that was a pain. No, the pain was in the fact that there were always discounts – as part of a promotion, or sometimes permanent discounts for one reason or another. It wasn't unusual for a customer to qualify for more than one discount at the same time. So…do you apply both discounts against the full price of the call? Or do you work out the second discount against the already discounted amount? Or do you just apply whichever one is biggest? Etc. And believe me, when you try to work out the equivalent price of a five minute call to Zakopane from Warsaw for a customer with a student discount, with an additional Christmas discount, during peak time, you start to lose the will to live.

I don't think there are too many pulse based billing systems left in the world, but while the time-and-distance based charging method still persists, mainly on fixed lines, billing has become a mind-bogglingly complicated area of technical and conceptual challenges.

The exponential growth of mobile (take a look at our "Rise of Mobile Phone Adoption" data visualization [i]) started to move billing away from the whole time-and-distance thing, and introduced the concept of 'bundles'. The differentials now could be between whether your call was to someone on the same network, or on a rival mobile network, or a fixed line provider; 'off-net' versus 'on-net'. In other words, along with 'bundles' came more billing complexity. The bills looked the same but the work going on behind the scenes to figure all that stuff out required many, many changes.

Prepay mobiles brought their own challenges. Now with prepay, the cost of what you were doing with your phone had to be calculated instantly. This led initially to simpler

tariffs; the necessary calculations of balance decrements and top-ups were carried out on platforms closer to the network on which the calls were trafficked.

That didn't last, though.

Pretty soon, prepay customers wanted the same sophisticated services as their post-paid pals. This led to the growth of 'real time' rating. Basically, this means that when someone made a call, or accesses a data service, all of the calculations needed to flow immediately across all systems to decide what sort of customer they were and what they were doing, then calculate a price according to their particular contract, while delivering a good customer experience. Real time processing remains a massive challenge to the industry today.

Then, starting in the 00s with the slightly underwhelming WAP (Wireless Application Protocol), the delivery of data services to mobiles took complexity for billing into the stratosphere.

Let me give you an example. Suppose a customer downloaded the latest DJ Snake video on your smartphone (I have no idea who DJ Snake is. I'm just trying to sound hip and modern, and I'm not sure that Jethro Tull are still making videos).

Here are the calculations you, as telecoms service provider, might have to make from that simple act:

- You might need to generate a charge of 50p to the customer; or, the customer might have a subscription which you need to record the download against to make sure it's still within a bundle.
- You might need to make a charge for 5mb of data; or, you might NOT need to make the charge so you need to look at their data bundle and ensure that it isn't decremented from it.
- You may have to pay a fee to the media company hosting DJ Snake's videos; and, you may have to make a royalty payment to the record company.

After you sort that out, then add to your considerations that the video may be shared to the customer's friends, on different networks, using different devices, and with different contracts.

All from one simple download. And much of it in real time.

It's quite complex to build a network and IT infrastructure that supports all of that.

Especially when you factor in:

- The network elements delivering the content are continuously evolving.
- The IT systems supporting the transactions are being replaced.
- The telco companies themselves are being bought and sold (you're never too far away from a merger or an acquisition in telecoms) and therefore, restructuring and migrating customers and data to new architectures.
- The Legal and Regulatory framework is constantly changing – pretty soon we're going to need to work out what Brexit means for all of this when we are no longer aligned with our EU partners. The legal and regulatory implications of that, along with the changes to roaming,, are potentially huge.

Of course, while all that activity is happening, customers still get a simple, easily explained bill. Add to that the latest triple- and quad-play offers from suppliers where your billing system must pull data in from DIFFERENT networks (fixed, 3G, 4G, and WiFi), make calculations, apply cross-promotional discounts, and present it to the customer in such a way that they don't resort to drink whilst trying to understand it!

The pace of change in what we want to send or receive over our networks is so fast that it is hard for me to predict exactly what our increasingly connected world will look like in FIVE years' time, let alone twenty-five.

I imagine that fixed telephony will be a thing of the past, and that the way we access our networks may not be via handsets for the most part but instead by watches, glasses, intelligent wallpaper, or subcutaneous implants (these last two are happening as we speak).

So there will still be services, and they will still be sold, consumed, paid for, settled with third parties, assured, protected from fraud, and reported to revenue. While all that continues, someone, like me, will need to figure it all out.

And customers will still get, inevitably, one simple bill. <>

Note:

[i] Cartesian: "The Rise of Mobile Phones: 20 years of global adoption", June 2015.

Mobile Wallet

Credit Card

1234 5678 9012 3456

1234

09/18

Touch and Pay

Credit Card

1234 5678 9012 345

1234

09

25 Years of Innovation:

Payments

by Ed Naef

1998

PayPal founded – enabling money transfers from bank accounts and credits cards to a broad range of sellers

2002

PayPal acquired by eBay, at a time when 70% of eBay auctions accepted PayPal and 25% used it as the transaction method for sales

2007

M-PESA launched in Kenya by Vodafone for Safaricom and Vodacom

2010

Square launched – allowing mobile phones to process credit cards

2011

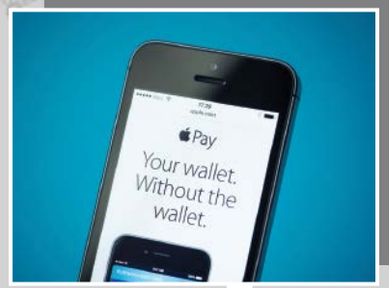
Google Wallet launched

2013

M-Shwari launched – a paperless banking service offered through M-PESA

2014

Apple Pay launched

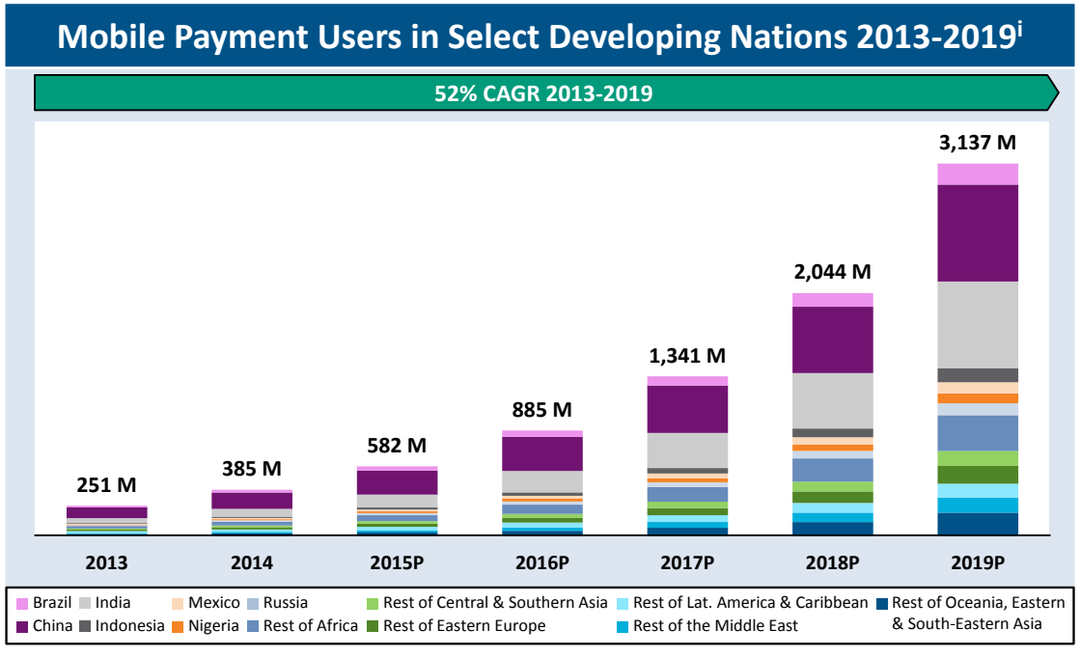


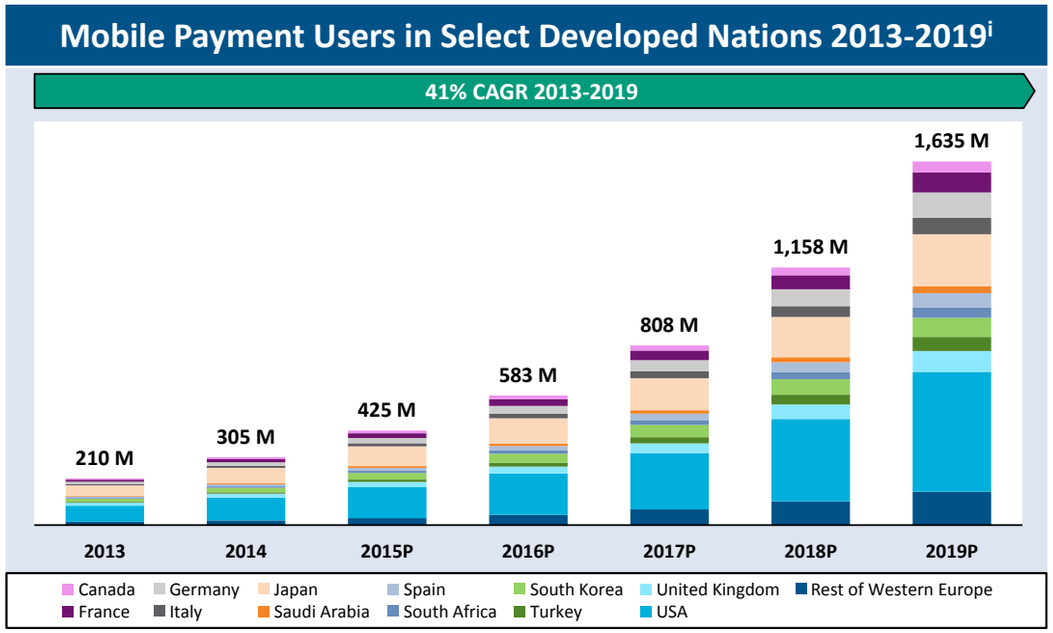
Payments

In this retrospective article, Ed Naef recounts the last 25 years of inventions, institutions, and motivations behind the move towards new payment systems and increasingly towards a cashless world. As we ease away from cash to digital, and become used to online and mobile modes of payment, who has gained and what is the potential for our quality of life?

Over the last 25 years, the financial systems for payments and credit have moved from the analog into a digital world. Increasingly, mobile is at the heart of retail payments in both emerging and developed markets. Looking forward to the next 25 years one can expect a move to a completely cashless society with entire alternative financial structures growing up around alternative currencies and next-gen mobile payments systems.

This innovation will lower transaction costs and bring billions of emerging consumers across the world into the formal financial system for the first time.





In developed markets, this will allow both more efficient transaction of commerce and more effective targeting of promotions and advertising. In developing markets, people entering the electronic financial system for the first time will materially improve their quality of life, helping to bring many out of poverty.

Looking back over the last 25 years of payments, it is clear how dynamic and changing this market has been. In 1991, ATM and credit cards were in wide use, but the significant majority of payments in the US were still by check or cash [ii]. Despite the wide adoption of credit cards and ATMs, it is striking just how new these technologies were at that time. In the mid-1960s the world's financial system was almost completely cash based. The first credit cards had just begun to emerge in 1965 with Barclaycard in the United Kingdom and Diners Club and American Express in the United States. These latter examples were the first 'open loop' systems where sponsoring banks transacted with each other vs. providing end-to-end closed systems. Credit cards were initially primarily used by business people and high income consumers. In fact, at this time, women were often unable to get credit cards themselves, requiring a male cosigner until non-discrimination legislation was passed in 1974 [iii]. The first ATM in the US did not appear until the end of 1969.

In the late 1990s, the early growth of the web and, in particular, the emergence of e-commerce over new platforms such as eBay forced both consumers, merchants

and financial institutions to become comfortable with conducting commerce more or less anonymously over the internet. Buyers on these platforms did not necessarily have credit cards or if they had cards, did not feel comfortable providing these details electronically. Similarly, small scale sellers and individuals in many cases did not have the ability to process credit cards or indeed have any desire to develop this capability. Into this gap entered PayPal, which allowed money transfer from bank accounts and credits cards to a broad range of sellers without directly disclosing bank and credit card information. Before eBay acquired PayPal in 2002, 70% of eBay auctions accepted PayPal and 25% used it as the transaction method for sales [iv].

Of course, today, electronic payments of all sorts (including mobile payments) are far more prevalent. In the US only 32% of US transactions are cash according to 2015 Federal Reserve Data, and 9% by value [v]. Cash dominates small value payments but all other payments have become electronic (excepting checks which are still 19% of payments by volume in the US). In part, this shift away from cash has been driven by steady inflation over that time period. From personal example, the original Bill of Sale for a 1966 Ford Mustang that I once owned was under $2000, in a time when $100 bills were already circulating. One could hypothetically put the cash for a new car into one's wallet!

The most exciting changes of the last few years has been the evolution of mobile payments. Since Square launched its service in 2010 (allowing mobile phones to process credit cards) and since Google's initial foray into mobile payment via Google Wallet in 2011, there have been a wide range of market entrants driven by banks, startups, mobile carriers and retailers including Isis/Softcard, Levelup, CurrentC, ChasePay, and eventually Apple Pay in 2014 (just to name a few). Mobile payments and banking are today mainstream and Apple Pay, Android Pay and Samsung Pay are increasingly being used to conduct retail transactions. These new platforms provide a more attractive retail experience for the consumer and provide a compelling platform for promotion and consumer engagement. These platforms allow consumers to bypass long lines to purchase coffees through app-based purchasing and can shave precious seconds from the retail purchase through NFC contactless payments. The NFC technology enabling many of these payment schemes was based on early RFID technology from NXP semiconductors developed initially almost 25 years ago and developed since by Sony (FeliCa) and the NFC forum, among others.

While mobile payments drive evolution in developed markets, they are already creating financial revolution in developing markets. The impact of mobile payments in the developing world will be profound and life changing for many of the world's poorest who will in many cases enter the formal financial system for the first time. The World Bank estimates that less than 41% of adults in developing countries have a formal bank account and only 20% of adults living in extreme poverty [vi]. Most of these low income consumers are active economically but conduct transactions purely in cash and have little means to build savings and less access to credit. Many in the development community believe that getting access to income smoothing mechanisms such as microcredit loans and small saving products can help customers avoid the access barriers, high transactions costs and occasional illiquidity of the formal electronic and cash-based financial systems in these countries.

Emerging markets have seen the most significant adoption of mobile payment and mobile financial services. M-PESA and M-Shwari (launched in 2007 and 2013 respectively), in Kenya are frequently cited examples, allowing both for rapid small value payment and savings and loan products. These services allow consumers across the income strata to quickly pay and receive payment for services in stores and to transfer money to individuals across the country (for example, sending money back to relatives in home villages).

Research suggests that there will be more than 1 billion users of these mobile payment services in 2017 and that users will quickly triple thereafter [vii]. At scale and maturity, mobile payments have shown that they can become almost a parallel monetary system. M-PESA is broadly adopted by Kenyans, and payments over its network are equivalent to 85% of GDP [viii].

Looking forward, we can expect greater and greater adoption of mobile and electronic services. Many, in fact, believe that we will shortly enter a fully cashless financial system in many countries. Ken Rogoff notes in his recent book that there is $4,200 in circulation for every man, woman, and child in the United States, of which 80% is in $100 bills [ix]. Since according to Federal Reserve data, the average American carries around about $60 at a time, one can assume that the majority of this cash is abetting criminal activities and tax evasion around the world (or more positively, providing stability to fragile countries unable to effectively manage the value of their own currencies). While

the seigniorage benefit of this to the US Treasury is substantial, a move to cashless society enabled by mobile and electronic payments could create a governance windfall by driving more activity into the formal financial sector, increasing tax compliance and reducing criminal behavior.

In emerging markets, the benefits of moving away from cash to electronic retail payments will be most significant. For example, On November 8th 2016, Modi, the Indian Prime Minister surprised the nation by declaring on TV that 1.25 billion people had two weeks to exchange $200 billion of their high denomination bills for new currency or deposit them into a bank [x]. The rapid nature of this transition has created substantial challenges for many consumers with the objective of forcing large holders of black or gray market cash into the formal sector and reducing cash payments in corrupt activities.

Some Scandinavian and European countries are leading the charge into the completely cashless future. Belgium currently processes 93% of consumer transactions electronically and prohibits cash payments larger than a certain value. In Sweden, many retail establishments no longer accept cash and about half of the countries' bank branches don't allow cash deposits or withdrawals [xi].

As cash gives way, in the future we may see the combination of crypto-currencies (such as Bitcoin) and mobile payments to create complete parallel financial systems with lower transaction costs and, if advocates are to be believed, more stable currency values, unshackled from the inflationary bias of government managed fiat currencies. This cashless future of electronic and mobile financial services will be a more controlled, lower cost, lower friction world with more financial inclusion of the world's global poor.

The payoff from this move to a digital, mobile cashless future will be profound both in quality of life and poverty reduction. However, the transition will not be painless and there are prosaic concerns. The most common payments use case for cash in the US, according to the Federal Reserve, is for "gifts and transfer to other people". In a cashless world, how will the Tooth Fairy delivery her dental bounties? Will she Venmo children from her account at the Bank of England? Will Grandma transfer Bitcoin to her grandchildren on their birthday? We look forward to building the answer with you over the next 25 years. <>

Notes:

[i] Ovum. "Mobile Payments Forecast: 2014-2019" (Dec. 2015). Subscription required.

[ii] Federal Deposit Insurance Corporation (FDIC) Banking Review. Updated 29 Oct 2004.

[iii] Eveleth, Rose. "Forty Years Ago, Women Had a Hard Time Getting Credit Cards." Smithsonian.com. 8 Jan 2014.

[iv] Jackson, Eric M. "How eBay's purchase of PayPal changed Silicon Valley." Venture Beat. 27 Oct 2012.

[v] CPO Market Analysis Team. "The State of Cash: Preliminary Findings from the 2015 Diary of Consumer Payment Choice." Federal Reserve Bank of San Francisco. 3 Nov 2016.

[vi] Financial Services for the Poor. Bill & Melinda Gates Foundation. Web page. 13 Dec 2016.

[vii] Mobile Payments Forecasts: Consumer Services. Ovum Knowledge Summary. 2014.

[viii] Genga, Bella. "Safaricom of Kenya Talking to Banks to Grow Mobile Money." Bloomberg Technology. 11 May 2016.

[ix] 'The Curse of Cash' Makes Case for a World Without Paper Money. NPR. 1 Sep 2016.

[x] Shah, Hasit. "India Wants a Cashless Society. But There's a High Cost." Slate. 28 Nov 2016.

[xi] Heller, Nathan. "Imagining a Cashless World." The New Yorker. 10 Oct 2016.


TV
NEWS

25 Years of Innovation:

Pay TV

by Tim Jacks

Key events in the UK Pay TV market:

1991

10%

of TV households in the UK have Pay TV

1992

Premier League kicks off, sparking growth of cable and satellite TV subscriptions

1998

ITV launches On Digital (Pay TV over Digital Terrestrial TV)

2002

Freeview launches in 2002, slowing Pay TV adoption

2006-11

Sky services propel Pay TV growth

2012

Analogue switch off (ASO); YouView and Netflix launch services in the UK

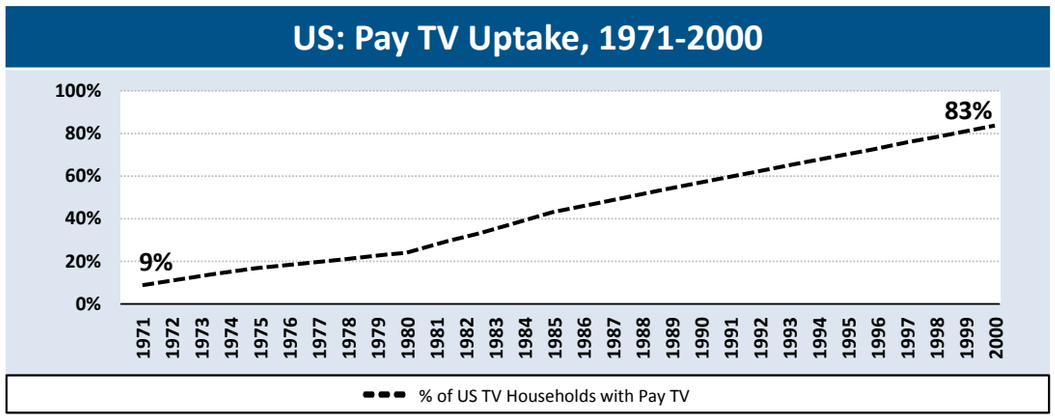
Pay TV

In this retrospective article, Tim Jacks charts the growth of Pay TV using the Bass Diffusion model and 25 years of challenges and triumphs in the UK television market. Will the UK stay the course and follow the uptake of Pay TV in the US?

This is the story of how Pay TV has grown in the UK over the last 25 years… and where it might end up in another 5 years' time, as seen through the lens of the Bass Diffusion model of product adoption (more on that later).

But we start by having a look at the US TV market. Everyone knows that Pay TV is fundamentally different in the UK from the US, right? Our American friends love TV in a way that we just can't comprehend – they can't get enough of it, so over 80% of households pay for TV, whereas here we have better things to do, so we'll never see more than 50% of households subscribing to Pay TV. Right?

Well, not quite. You see, Pay TV penetration changes pretty slowly, and we sometimes forget that Pay TV has existed in the US since around 1950, gradually spreading and growing throughout the country. In 1971, only 9% of households with TV were paying for TV (our definition of take up). 25 years later, in 1996, this figure had reached around 70% [i]. So how does this compare to the UK?



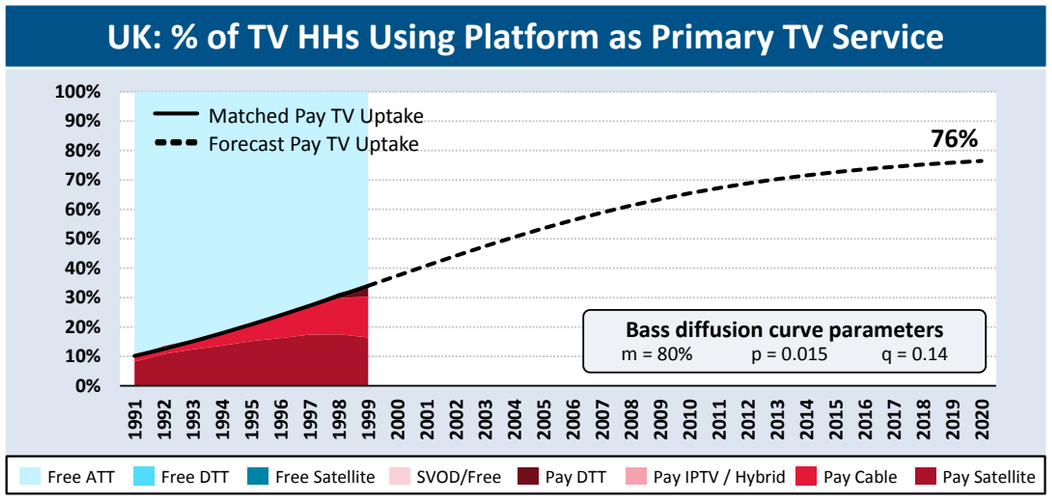
Well, in the UK, Pay TV started in around 1985, and didn't really take off until BSkyB was formed from the merger of British Satellite Broadcasting and Sky Television in 1990 (an exciting story in itself). At the end of 1991 (25 years ago!), Pay TV was in around 10% of TV households – about the same position that the US found itself in 45 years ago in 1971.

Rupert Murdoch created the Premier League in 1992, got people to start paying to watch football, and things went from there. Cable operators (mainly NTL and Telewest) responded by expanding their networks, and growth of both cable and satellite subscribers followed.

This is where the Bass Diffusion model comes in. It's one method of forecasting the adoption of new products – not perfect, but tends to do pretty well. The Bass model takes three parameters: m = the ultimate addressable market; p = coefficient of innovation (how quickly early adopters will take up the product); and q = coefficient of imitation (how quickly everyone else will take up the product). The average values of p and q have been found to be 0.03 and 0.38 respectively, but these vary across products.

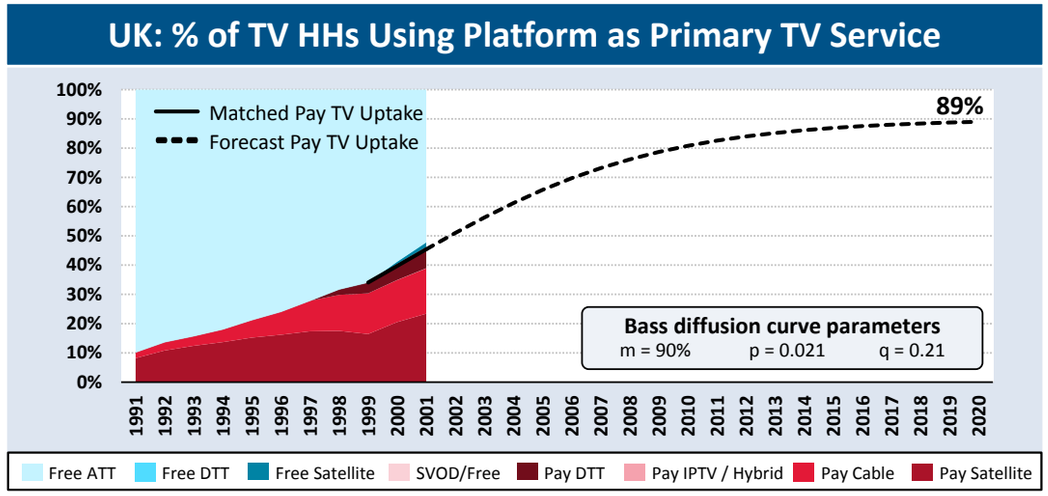
If we use the Bass model to match Pay TV adoption in the UK from 1991-1999, assuming pessimistically that we can only ever hope to reach US levels of adoption of 80% (m), we get values for p and q of 0.015 and 0.14 (half those of average products). As I said, Pay TV adoption is slow!

But look what it predicts – 76% Pay TV adoption in 2020, roughly in line with US progress after the equivalent amount of time! [ii]



Unfortunately, things aren't that simple though. The Bass model prediction only stands when the product isn't changing.

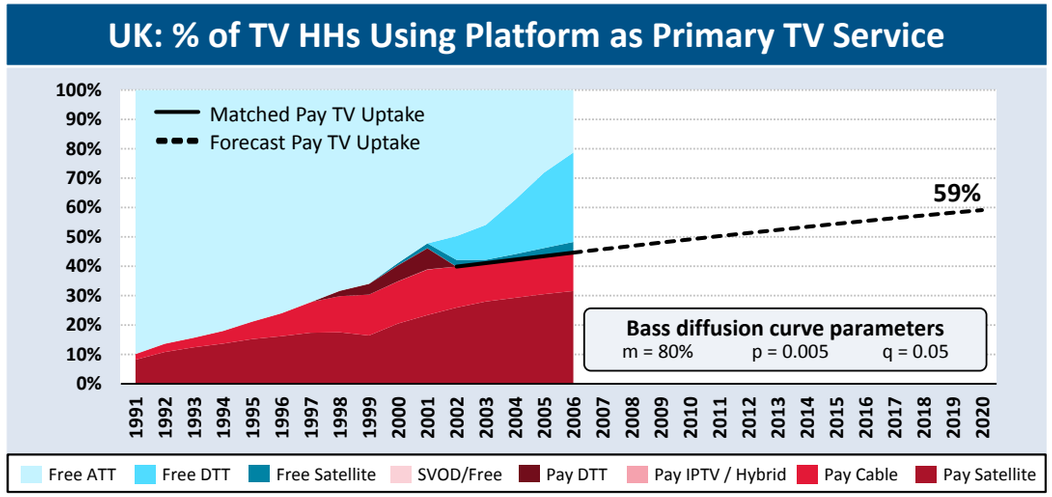
And in 1998, the Pay TV product in the UK changed, significantly. ITV (with the help of Cartesian [iii]) launched their On Digital service – Pay TV over digital terrestrial television (DTT). It was low-cost Pay TV, and subsequently adoption rocketed – when we match our Bass model to the new take up profile, it looks like we might shoot through the "80% barrier", to achieve even greater Pay TV adoption than in the US by 2016 and onto 2020.



But some things are too good to last. And On Digital (rebranded to ITV Digital) went into administration in 2002, unable to afford the Premier League rights it had gambled on (and allegedly the victim of sponsored piracy).

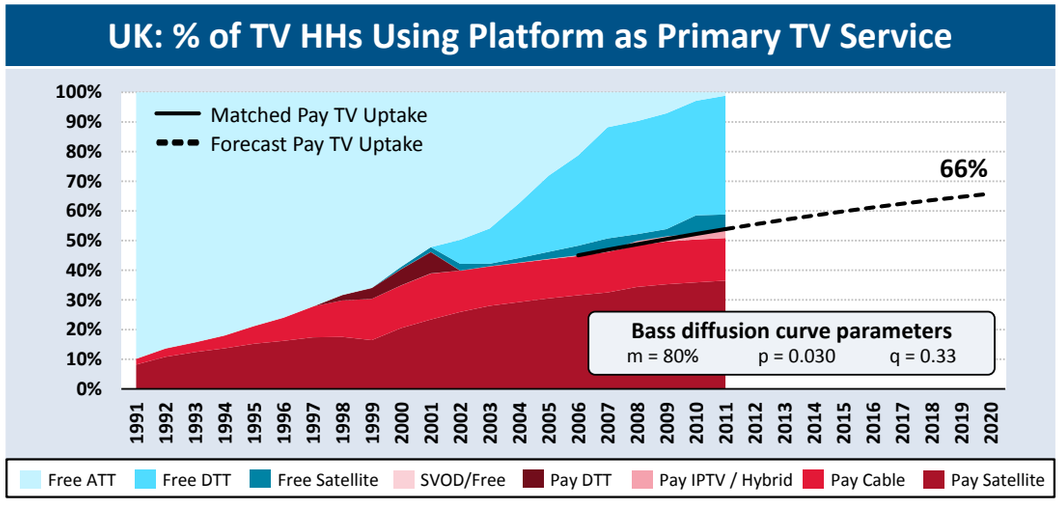
Pay TV adoption took a double blow: not only did it lose the new Pay DTT subscribers, but out of the ashes was born Freeview – suddenly multichannel TV was available without a subscription. With the rapid growth of Freeview, Pay TV adoption slowed dramatically.

Our Bass model now has miserable p and q values of 0.005 and 0.05. It looks like Pay TV will never reach that 80% mark. Maybe we are different from our friends across the pond after all!



Never fear, the industry always has a solution, and 2006 to 2011 saw renewed growth from Sky, and help from the addition of new IPTV services from BT and Tiscali (now TalkTalk TV). These new IPTV services weren't the most successful during this period, but would provide the basis for some important changes to the environment.

2012 was the year of analogue switch off (ASO) in the UK – by the end of 2011 pretty much every household in the UK had multichannel TV, with more using Freeview as their primary TV service than any other platform. The challenge for the industry was to sell Pay TV to these households. And the solution came quickly (although it didn't feel like it at the time), and was based around the over-the-top (OTT) revolution.

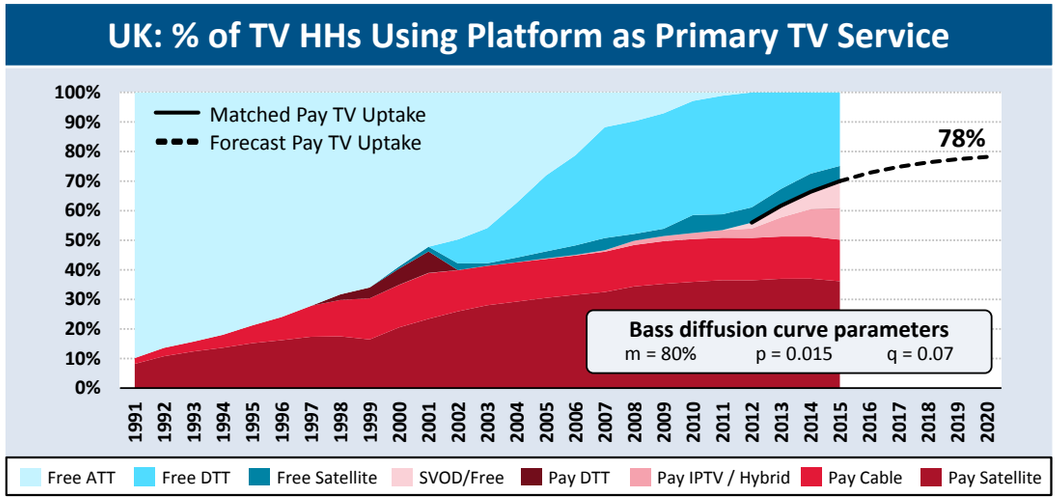


YouView was created by a consortium of broadcasters, and the two operators of the previously mentioned IPTV platforms, BT and TalkTalk. The platform was intended to allow easy access to catch up and on demand OTT services through a DTT set top box. Unwittingly, YouView morphed into a vehicle on which BT and TalkTalk launched new low-cost Pay TV offerings, which both saw rapid growth.

At the same time, the Netflix revolution reached the UK, launching here in 2012. Launches of OTT-based subscription VOD (SVOD) products from Sky (Now TV) and Amazon quickly followed.

These two product types combined started a new era in Pay TV adoption. In our chart, we show the SVOD/Free category, meaning homes that pay for an SVOD service in combination with some other form of free TV (Freeview/Freesat), or even with no TV set at all. (Note that the actual number of SVOD subscribers is much higher than this, with the majority in households with cable or satellite TV).

So what happens now when we apply our Bass diffusion curve? Nearly 80% Pay TV adoption by 2020. Phew!



Of course, we're ignoring the impact on ARPU (not enough space here) of these recent changes, but in terms of understanding the timescales on which Pay TV growth works, and the drivers that can affect it, hopefully we've shed a little light.

With Pay TV penetration in the US now falling due to the impact of cord-cutting and cord-nevers, and the increasing influence of global players, we see a potential future where the US and the UK really don't look that different when it comes to Pay TV. <>

Notes:

[i] US data sourced from World Almanac & Book of Facts: "U.S. Households with Cable Television, 1977-1998", January 2000; "Television History – The First 75 Years". Available at: www.tvhistory.tv/facts-stats.htm.

[ii] UK data compiled from BARB UK TV Landscape 2016 Report, Ofcom UK Communications Market Report (August 2011), and "Sky High" by Mathew Horsman (published in 1997); Cartesian analysis.

[iii] Cartesian acquired Farncombe Technology Limited in July 2015.

25 Years of Innovation:

Content Security

by Brian Paxton

1995

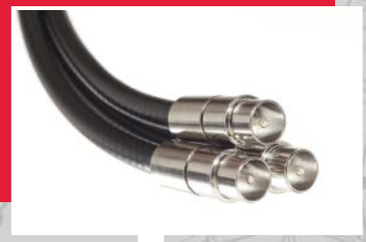
First CD writers become available for PCs at a reasonable price

1998

Launch of the Rio PMP300 MP3 player, as an alternative to audio cassette; DMCA passed in the US; Napster launches a year later

2000

Broadband becomes available; Card Sharing becomes practical



2001

Napster shut down; BitTorrent P2P protocol released

2003-07

The Pirate Bay launched as well as the Xbox Media Center (now known as KODI); YouTube launched ('05); BBC iPlayer launched ('07)

2008

IFPI: Online piracy rate in the UK at 95%; Spotify & Roku launched

2012

MegaUpload closed down

2016

The start of Facebook Live and YouTube Live

Content Security

In this retrospective article, Brian Paxton reviews the content security challenges that have arisen as media turned to digital over the last 25 years. Starting with music and then looking at TV, we see how these industries have evolved over time to combat content piracy.

The media industry has evolved enormously over the last 25 years. In 1991, we were consuming content over analogue broadcast TV and recording our favorite shows on our VHS recorders. Now in 2016, we are consuming content at home and on the move, across a wide variety of devices. What's more, the range of content presented to us is of a higher quality than even before and we're able to watch it when we choose to. Throughout this time, rights owners have sought to protect their content from illegal distribution.

The Music Industry's Answer to Piracy

Within the media sector, the music industry has arguably gone through the greatest upheaval in the last 25 years. Back in 1991, most music piracy was on audio cassette. Digital Audio Tape (DAT) was available, but wasn't widely adopted outside Japan; and CD writers had yet to appear. Piracy was therefore largely limited by degradation in quality of subsequent tape copies, and the size of personal contact networks.

That all changed with the release of the MP3 audio standard in 1993. MP3 provided a means of compressing digital music tracks: this small file size made the music 'portable'. MP3 players started to appear a few years later, popularized by the Rio PMP300 player in 1998. As digital files, MP3 music could be replicated with ease and it wasn't long before illegal file sharing took off. This was the first time that consumers had the ability to share bit-perfect digital copies of music 'ripped' from CDs.

The combination of digital copying, internet access and peer-to-peer networking led to consumer copyright infringement on an industrial scale. The file-sharing service Napster was launched in 1999, with rapid take up. Even though most home consumers only had slow dial-up internet connections, the popularity of Napster grew. In university campuses with faster connections, usage was high. The service's usage peaked in 2001, but was shut down later that year after an injunction taken out by the Recording Industry Association of America, on the grounds of illegal transfer of copyrighted music. Unfortunately, the result was an upswing in usage thanks to the publicity generated by the court case!

In the same year, Apple launched iTunes, which gave users the ability to download music onto Apple portable devices and playback on laptops. In time, Apple launched its own music purchase store, allowing sharing of content between a limited number of 'household' devices. Usage restrictions were initially constrained by use of FairPlay, the Apple Digital Rights Management (DRM) system, however this was removed by 2009 following a similar move by Amazon.

To the present, iTunes remains a popular source of content, and its launch turned the music industry business model on its head. Purchasing albums is no longer the norm, and has been replaced by single track purchases. Consumers have found it easy to download and share large amounts of content, which has eroded the revenue stream of the distributors and recording artists. Since 2008, the growth in streaming and download services, such as Spotify, have further changed the scene, with the concept of 'ownership' of material by a user giving way to a 'perpetual subscription' model. Indeed, Apple now offers a subscription based service too.

With TV Content, Piracy Finds New Routes

Turning now to video… In the early 90s, Pay TV delivery was exclusively by analogue cable or satellite delivery. TV operators protected their content against illegal access using a Set Top Box and consumer smartcard. However, the maturity of the technology within smartcards at the time was low, and many systems were hacked. Experts – backed by organized crime – would reverse-engineer smartcards to produce clones for sale, or to develop code allowing legitimate smartcards to be reprogrammed or simulated in software. These pirate smartcards allowed the consumer to upgrade to an 'all you can eat' package for free. In response, TV operators, in conjunction with the system security vendors, then issued software downloads to patch the problem. Sadly,

this only 'bought time' against an attack, and ultimately new smartcards (at substantial cost) had to be issued to consumers, before the cycle began again.

This pattern of attack continued through the late 90s as TV operators migrated to digital delivery platforms. As Pay TV became more popular around the world, the interest in obtaining services illicitly also increased. This was (and still is) seen as a significant income opportunity for professional pirates and hackers in cahoots with organized criminal networks.

The advent of broadband and always-on internet led to a rapid rise in a new method of circumventing access controls: so-called key sharing (also called card sharing). Key sharing is achieved by intercepting the key used to encrypt the broadcast signal as it passes between the smartcard and STB decoder chip. Legitimate card subscriptions are used to intercept these keys which are then distributed over internet in real time to key sharing 'subscribers'. Anyone with a generic STB can subscribe to a key sharing service.

In the last few years, large operators have been getting on top of key sharing by rolling out their most advanced 'countermeasures' (hardware based key encryption). This, along with the ubiquity of high speed broadband, has shifted the focus of illegal content sharing to re-streaming. Content is captured, re-encoded and re-distributed over internet in real time, to be made available to users through a simple app or website. The experience can be of variable quality, ranging from free streams infested with pop-up ads to fairly sophisticated paid services giving 'professional looking' EPGs.

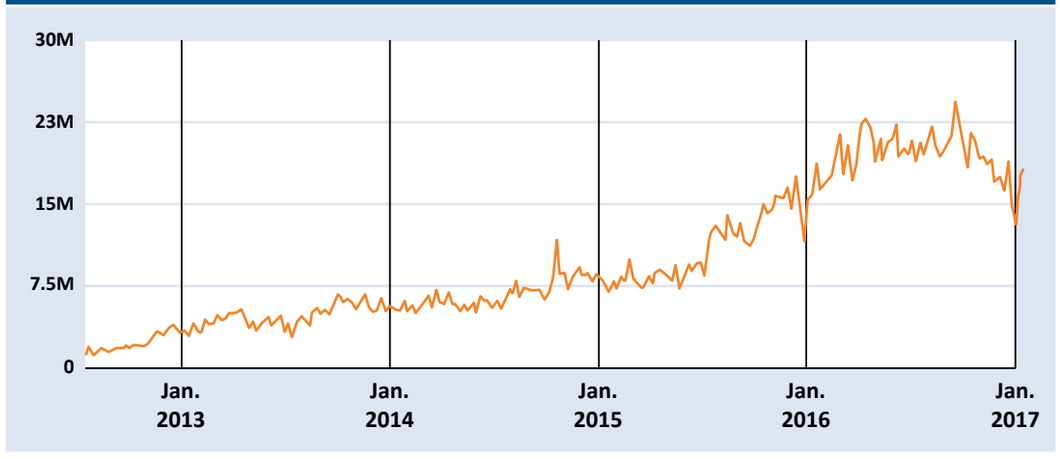
Re-streaming services are very convenient for the end-user, and are regarded as today's pre-eminent threat to Pay TV. Low-cost IPTV STBs are readily available to access these services which can offer many hundreds of channels from around the world in a single easy-to-obtain package for a low monthly fee. Key sharing still requires a physical STB and card, and access to the cable network or a satellite dish; re-streaming services require little more than a device with an internet connection.

Piracy Goes Social

The introduction of live streaming services such a Periscope and Facebook Live have shifted the goal-posts in the last two years. Everyday social media users can now re-stream content to their friends using a simple smartphone app. For rights owners, there is no longer a small number of illegal re-streamers to target, but rather, many thousands of "nano-pirates". The Mayweather v Pacquiao fight in 2015 was heavily pirated using Periscope and other apps.

Rights owners are responding in a number of ways to this new threat. A holistic view is required to identify the sources of illegal streams, and a range of measures – technological, legal and commercial – are being used to counteract the threat. New technologies are being deployed to tackle piracy at every stage of the delivery chain. For example, fingerprinting technologies allow for quick detection of uploaded copies of copyrighted content, and watermarking content can be used to identify the source of the content at either the operator or individual subscriber level.

Google: Volume of Requests to Remove or Delist Content Due to Alleged Copyright Infringement, since July 2012[i]



What Next?

And so it continues. New technologies give opportunities to both pirate and protect content. However, with content protection methods getting more sophisticated, content now available via a number of legitimate channels, and the existence of a number of payment options for consumers, we may see the battle against piracy turn towards the content owners favor. <>

Note:

[i] Google Transparency Report.

Contributing Authors:

Tom Thomas and Pascal Hetzscholdt


START
VIBRATION
MODE

25 Years of Innovation:

Video Games

by Rishi Modha

1993

Initial release of Doom, the first smash-hit first-person shooter, installed over 20M times within the first two years

1996

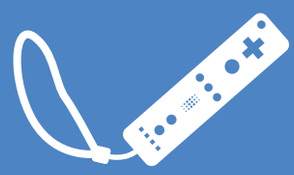
Sony enter the console market with the release of the original PlayStation

2002

Xbox Live, the early blueprint for today's online console gaming, launches

2006

Nintendo launch the Wii and bring casual gaming to the masses, with over 100M units sold

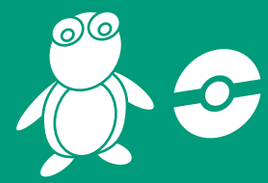


2009

Angry Birds launches on the iPhone, ultimately reaching 2B downloads across multiple devices

2016

Virtual and augmented reality hit the market with the release of the Oculus Rift and Pokemon Go



Video Games

In this retrospective article, Rishi Modha journeys through 25 years of video games. We look back at the fun of 16-bit consoles, the emergence of multiplayer gaming, the success of online and 3D play, and the potential of the immersive experiences of augmented and virtual reality.

I've lost many hours of my life to games. I'm sure I'm not the only one. Growing up, I postponed revision, chores and other immediate productive activities for just one more game. Even now, I can't help but occasionally succumb to suspending reality for just a little longer than initially intended. The devices, platforms, and modes of interaction have changed over time, but looking back, the same magic has always been there.

1991: Speeding Through the Late 16-bit Era

Visually, games start to look outdated very quickly. Tracing back to 1991, where our retrospective begins, it's striking how primitive graphics were compared to today's standards. Though in terms of overall video game history, we may have skipped past Pong, arcade dominance and the growth of homebrew development on early personal computers, the overall landscape at this point in time is unrecognizable compared to now.

Nintendo and Sega were the dominant console manufacturers in the 16-bit era, and 2D scroll platform and combat titles were all the rage. Sonic the Hedgehog, the flagship Sega title released that year, was quite literally a blur - enchanting gamers for hours at a time with unparalleled gameplay speed. Who knew that the simple addition of momentum to running and jumping could be so engaging?

1992-95: The Emergence of 3D

The next dimension of enhancement was visual, with Wolfenstein 3D introducing the world to the first-person shooter genre in 1992. It wasn't the most influential early shooter, however, with more fond memories likely to be reserved for Doom, which was released a year later and distributed widely as shareware. Doom captivated gamers by pioneering game mechanics which can still be recognized in today's big-budget titles. The game was one of the first to include networked multiplayer modes and specific policies banning play during the work day had been put in place at Intel, Lotus Development and Carnegie Mellon University. It turns out that spending time virtually gunning down colleagues distracts from actual productivity.

1996-2000: Sony Enter the Market, Nintendo's Golden Era

The next generation of console releases brought in an era of gaming that more closely resembles today, with ubiquitous use of 3D graphics and optical discs as the format media of choice. Sony dominated sales with their 1996 console debut, the PlayStation. Tomb Raider showcased the cinematic production values the new generation of consoles made possible.

Despite selling fewer units overall, Nintendo 64 arguably played host to a greater volume of classic titles. The likes of Mario Kart 64, Goldeneye 007 and Super Smash Bros are fondly remembered and still regularly played by gamers today... occasionally even in Cartesian's own Boston office. Nintendo also dominated handheld gaming during this period; the release of the first Pokémon games in 1996 sparked a worldwide craze that's been recently reignited. The release of the Gameboy Color in 1998 served only to reassert Nintendo's mainstream dominance and represented the peak of their overall cultural and creative influence.

2001-2005: Online and Interactive

The next frontier for gaming was online: Microsoft's entry into the market with the launch of the Xbox in 2001, accompanied by the first in the iconic Halo series, signaled the direction ahead. Growing availability of broadband internet services in the early 00s paved the way for Xbox Live to succeed where the Sega Dreamcast's online efforts had failed. Though Nintendo and Sony both introduced online gaming capabilities on their respective consoles, Microsoft's offering was more comprehensive and integral to the intended experience. Despite this, the Xbox was not the best-selling console of the generation. The PlayStation 2 capitalized on exclusives such as the Gran Turismo and

Grand Theft Auto franchises to sell over 150M units [i] worldwide, which makes it the best-selling home console ever.

The Nintendo Gamecube struggled to make a dent, though this was offset by the incredible success of the Nintendo DS. Released in 2004, the intuitive touch-controlled dual-screened handheld console set the path for the impending explosion of mobile gaming a few years later.

On the PC, World of Warcraft made its debut in 2004 and has been going strong ever since. The subscription-based massively multiplayer online game has ensnared upwards of 100M users into its virtual worlds across its history and still continues to dominate today.

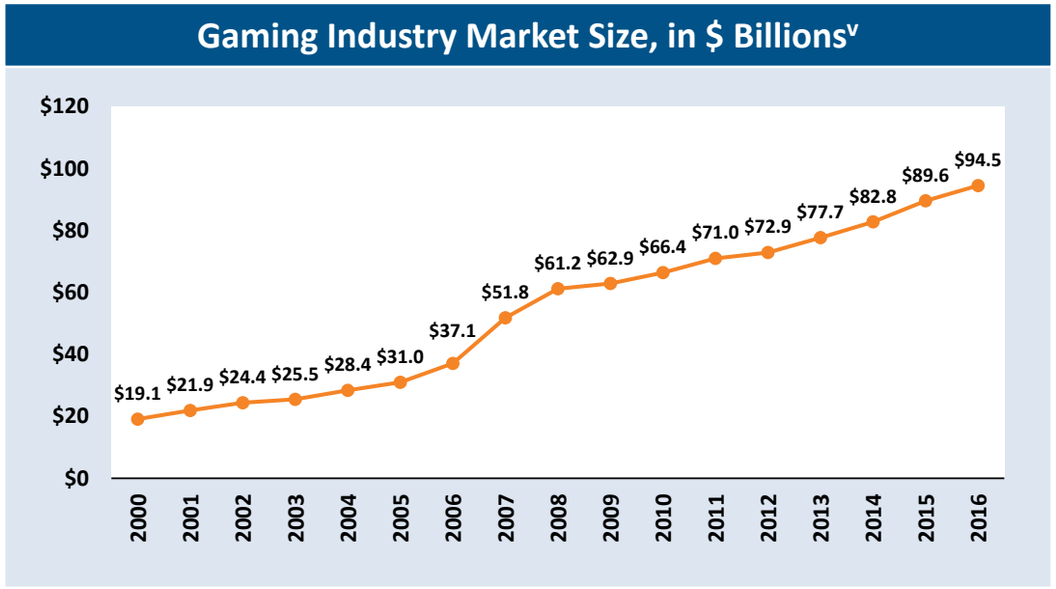
2006-2011: Everyone Can Play

The next few years saw gaming open itself up far beyond its traditional demographics, with the advent of casual gaming. Nintendo released the Wii, complete with motion control, in 2006 and allowed the whole family able to play games together. Wii Sports, bundled with the console, was made for different generations to go toe-to-toe and could be found in over 100M [ii] households, the greatest sales of that console generation.

The PlayStation 3 and Xbox 360 followed similarly from the previous generation, though the volume of exclusives began to decline, with most popular titles available on both platforms, such as the likes of the Call of Duty series. Sales volumes were similar and both offered strong online gaming experiences, catering to traditional gamer demographics.

The release of the iPhone in 2007 and the later resultant ubiquity of smartphones paved the way for an explosion of mobile gaming. Angry Birds, first released in 2009, is a textbook example of the simple, yet addictive gaming capabilities available on mobile devices, which coupled with distribution through app stores, culminated in over 2B [iii] downloads. The growth and ubiquity of smartphones as gaming devices would later erode Nintendo's strong handheld market position.

Minecraft, released first in beta on PC in 2009, was a significant non-traditional game that reached mass audiences. The open-world sandbox construction sim is the second best-selling game of all time, with over 100M [iv] copies sold after its full release in 2011.



2012-2016: Gaming Today

Growth in production and marketing budgets has seen gaming on the Playstation 4 and Xbox One begin to rival film as the dominant form of big-budget entertainment. Grand Theft Auto V, released in 2013, had an estimated total budget of $265M [vi]. Diminishing returns on graphical improvements have seen greater emphasis placed on narrative depth, with 2013 release The Last of Us obtaining widespread acclaim for effective storytelling and emotional impact previously unseen in the medium.

Mobile gaming remains popular, with the likes of Candy Crush and Clash of Clans remaining addictive for hundreds of millions of people. For some, low development costs have resulted in extreme success. Flappy Bird, created and launched by Nguyen Ha Dong over the course of a few days in 2013, quickly went viral. The game was soon generating $50k [vii] revenue per day, until it was pulled from app stores in early 2014.

Adjacent forms of entertainment, such as eSports and Let's Play videos, have emerged and rapidly exploded in popularity. Tournaments for popular free-to-play games, such as League of Legends, garner massive audiences and offer multi-million dollar prizes. Top YouTubers, such as PewDiePie, rose to fame providing commentary whilst playing games. Today, he holds the top ranked YouTube channel with 14B video views and

nearly 50M subscribers [viii]. Gaming and related entertainment is bigger than ever.

The success of Pokémon Go in 2016 showed the magnitude of scale that mobile-based augmented reality games can realize. In addition, it demonstrates a potential route to future success for Nintendo. They can capitalize on the strength of mobile gaming through brand licensing from its wide range of popular title franchises and continue to innovate with new formats. This sentiment is contrary to their recent performance in the hardware market. The Wii U struggled to make as big an impact as its predecessor and the growth of smartphone gaming has severely impacted the overall handheld market size. Despite this, their future still appears positive, even if they are no longer in contention to be the leading hardware player.

The Future

We are beginning to see gaming move into augmented and virtual reality. In 2016, the Oculus Rift had its first commercial release and Sony launched the PlayStation VR. It will take some time for this shift to gain widespread traction, but the future is clear.

This presents a significant opportunity and offers a range of exciting possibilities. Gaming is uniquely appropriate to serve as the narrative medium for storytelling in virtual reality, given the need for interactivity for full immersion in a virtual world. Feeling fully present in a virtual world seems fanciful, but we're surely not too far off from that point. Maybe within the next 25 years. Either way, the fun and magic that games provide will certainly continue. <>

Notes:

[i] Ewalt, David M. Forbes: "Sony PlayStation 2 Sales Reach 150 Million Units", February 2011.

[ii] Robertson, Andy. Forbes: "Wii Sports Club Brings Record Breaking Top Seller to Wii U", September 2013.

[iii] Cramblet, Gavin. Forbes: "Why is Wii U a Failure?", February 2014.

[iv] Parfitt, Ben. MCV UK: "Minecraft sales pass 100m units", June 2016.

[v] Credit Suisse, Euromonitor, iResearch, KOCCA, UKIE.

[vi] Villapaz, Luke. IBTimes: "GTA 5 Costs $265 Million to Develop and Market", September 2013.

[vii] Hamburger, Ellis. The Verge: "Indie smash hit 'Flappy Bird' racks up $50K per day", February 2014.

[viii] Mogg, Trevor. DigitalTrends.com: "PewDiePie says he'll ditch his 50 million YouTube subscribers on Friday", December 2008.

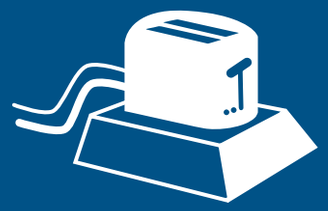
25 Years of Innovation:

Connected Devices

by Anne Gillard

1990

John Romkey creates the first Internet “device”: a toaster



1995

Siemens sets up a dedicated team within its mobile phones unit to develop machine-to-machine (M2M) industrial applications

SIEMENS

2008

The Internet of Things (IoT) is born. The number of “things or objects” surpasses the number of people connected to the Internet

2014

Investment in IoT development, platforms, and new startups explodes

2015

The IoT-GSI Global Standards Initiative is created, enabling the Internet of Things on a global scale

2016

Smart clothes, marketed at this time only to athletes, are set to over-take smart wristbands in sales

Connected Devices

In this retrospective article, Anne Gillard takes us to the early days of the Internet of Things and the first connected devices. With the number of devices expected to triple in growth in the next few years, we look back at the last 25 years of inventions and enablers that have brought us to the tipping point.

Connected devices are everywhere. Our phones, watches, vehicles, and even our home appliances are becoming connected to the internet and communicating with each other. With Fitbit's activity trackers, you can see the number of steps you take, your resting and active heart rates, and even how many hours you slept last night. With Nest's WiFi-enabled thermostats, you can save on your energy bill by programming different temperatures for different times of the day or week. Phillip's wireless LED lights allow you to easily control the color and intensity of your lighting to create the perfect ambiance. Yet connected devices are not just beneficial in and of themselves. By collecting and sharing information about your health, schedule, habits, and interests, your home or office environment will anticipate your needs and wants. Together with cloud-based applications, big data analytics, and machine learning, the networking of these devices is set to transform our lives.

The Beginning of IoT and the First Connected Devices

When we talk about connected devices, though, we really need to talk about the *Internet of Things,* a term first coined by entrepreneur and technology expert Peter T. Lewis in 1985. Even though it's been over 30 years, his definition remains accurate: "the integration of people, processes, and technology with connectable devices and sensors to enable remote monitoring, status, manipulation, and evaluation of trends of such devices" [i].

The early development of connected devices was a slow process, one that gathered pace with the growth of the internet, and drew from the research in related fields. The history of connected devices is not uniform or tidy, and is best understood as a patchwork of small inventions and minor breakthroughs, with contributions from academic and corporate bodies – from folks at universities such as MIT and Cambridge, and their counterparts at companies like IBM, Siemens, and Cisco.

For some, the original connected device was Olivetti Research's "active badge", which used infrared signals to communicate a person's location within a building. Each badge periodically transmitted a unique ID to a number of receivers, allowing computers to log the location and movement of data of each respective user [ii]. Developed between 1989 and 1992, the active badge system is often cited as a starting point for location tracking technology. In 1990, John Romkey, in cahoots with his friend Simon Hacket, created the first internet 'device': a connected toaster. Featured at that year's Interop conference, the toaster was linked to a computer and could be switched on and off using Simple Network Management Protocol (SNMP) over an IP network [iii]. This was technology that John was familiar with – having worked on the first implementation of TCP/IP at MIT, and later with IBM. While its creation was not as formal as the active badge system, this kind of half-haphazard tinkering was not unusual during the early years of IoT development.

As the internet was starting to take off, the buzz surrounding the far-reaching applications of connection began shifting from the academic sphere to the commercial. Recognizing the potential of wireless connectivity, in 1995, Siemens set up a dedicated department to develop and launch a product called M2M One, a technology that enabled machines to communicate over wireless networks. Largely designed for commercial use, M2M One had applications for POS terminals, vehicle telematics, and remote monitoring [iv]. In the years that followed, many other companies entered the space. Innovators and researchers started to look at effective ways to monetize these new technologies and capabilities in wireless technology, and M2M in particular.

The first connected devices available for consumers were expensive, difficult to use, and quite often, failed to attract buyers. The early 2000s saw the first internet-connected fridge from LG Electronics. With a retail price of over $20,000, it's no wonder that it had limited success.

In 2002, Ambient Devices released the first "glanceable" device, which changed its display based on information - weather forecasts, market trends, traffic information -

acquired over a wireless connection. Things were starting to pick up. In the same year, Nokia 3510 became the first mobile phone to provide GPRS internet services, marking the beginning of mobile data (with 3G and 4G to come!). And in 2006, the first HP Smart TVs were sold. The next year, Livescribe released its first Smart Pen, followed by Fitbit and its first activity tracker in 2009. By 2010, home automation began to take off, with Nest launching its connected thermostat, providing consumers with sleek, user-friendly home automation devices. This is part of what makes IoT so compelling: from forks and cups, to desks and chairs, to traffic lights, jet engines, and oil rigs, most everything can be connected. As connection becomes increasingly affordable and the components easier to develop, connected devices will become more prevalent, integrating themselves almost seamlessly into our lives.

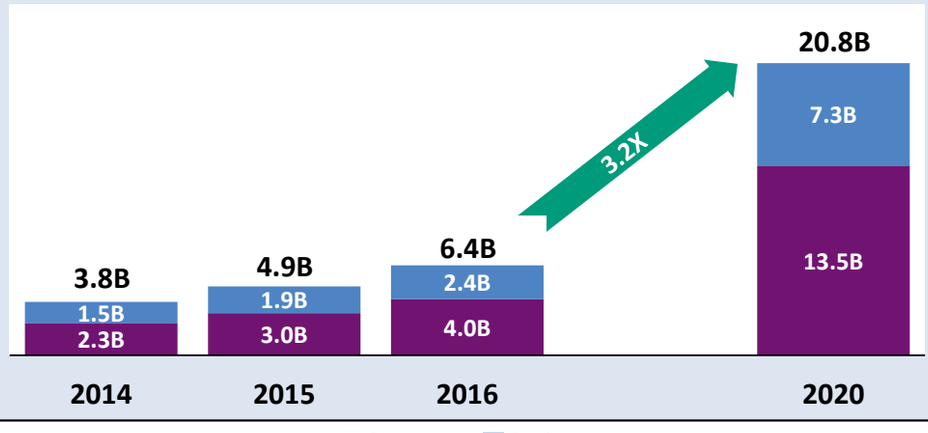
The story of connected devices is not complete, however, without acknowledging the roles of improved wireless M2M connectivity, enhanced computing capabilities, and better access to and speed of the internet. Technological progress and improved network infrastructure paved the way for IoT and connected devices. Short-range wireless communications protocols such as Bluetooth, NFC, WiFi and ZigBee overcame the inconvenience of wires. Whilst more recently low-power, wide area network platforms such as LoRaWAN and Sigfox have delivered cost-effective connectivity to even more things in even more places.

IoT Today and Tomorrow

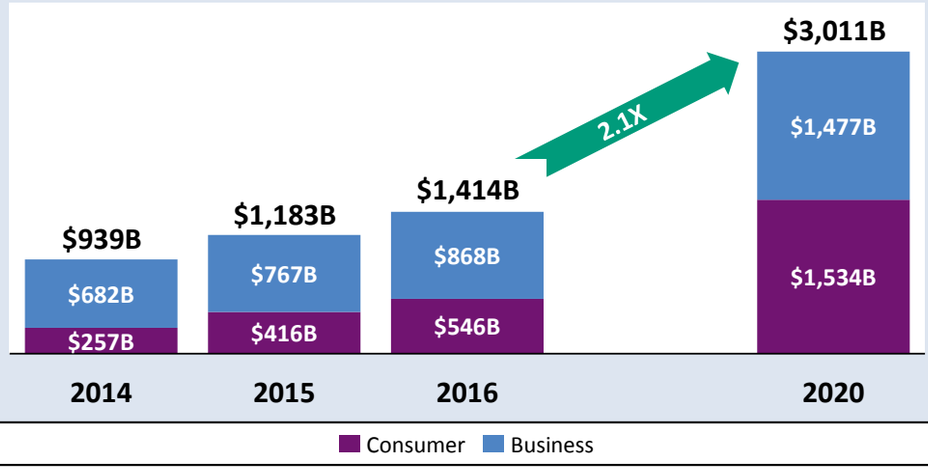
Given the level of technological innovation over the past decade – including the rapid advances in fixed and mobile broadband, and widespread adoption of mobile phones, laptops, and tablets – it should come as no surprise that we are on the brink of fully-connected lives. Gartner estimates that there are already over 4 billion consumer IoT devices. That number is expected to increase to more than 13 billion units by 2020, representing a $1.5 trillion-dollar global market [v].

IoT is not limited to consumer applications. On the commercial side, unit and revenue projections are close to those on the consumer side, with some 2 billion devices in use by enterprises, firms, agencies, and manufacturers today.

IoT Units Installed Base by Category (Billions of Units)



IoT Endpoint Spending by Category (Billions of Dollars)



Major corporations have recognized the opportunity that IoT presents, both as a sales opportunity and tool to improve their own operations. Amazon, Google, Microsoft, IBM, and Apple have developed or are developing their own proprietary IoT platforms and relevant solutions for consumers as well as businesses. Manufacturers like Rolls Royce are harnessing the power of big data and IoT to optimize engine performance, reduce fuel consumption, and minimize maintenance costs using predictive analytics. Oil and gas manufacturers like PG&E are monitoring petroleum supply assets, preempting

mechanical failures or identifying pipeline leaks as they happen. While consumers enjoy 'smarter' living, businesses will harness the power of IoT to reduce costs and improve efficiency across a variety of use cases and industry-verticals. Those hesitant to invest in this space risk falling behind. By the same token, those that invest too early, or make poor development decisions, could sink enormous sums of money for negligible returns. As is often true of new technologies, timing is everything.

Delivering on a Promise

The promise behind the inventions of IoT and connected devices was to make our lives easier by making our everyday devices smarter. From simple applications for comfort and leisure, to use cases delivering the very real benefits of energy savings, emissions reduction, healthcare improvement, and security enhancement, slowly but surely, we're seeing this promise being realized. Many of us have already experienced benefits, and consumers and businesses alike are embracing these new technologies. So although the growth in connected devices was slow over the last quarter of a century, expect to see explosive growth in the coming years. <>

Notes:

[i] "Correcting IoT History", *Chetan Sharma.*

[ii] Rhodes, Bradley. "A brief history of wearable computing."

[iii] "The Internet Toaster". LivingInternet.com

[iv] Press, Gil. "A Very Short History Of The Internet Of Things."

[v] "Gartner Says 6.4 Billion Connected "Things" Will Be in Use in 2016, Up 30 Percent From 2015."


http://www.

25 Years of Innovation:

The Web

by Michael Dargue

1990

Sir Tim Berners Lee invents the Web

1993

Only

623

websites exist

1994

AT&T buys first ever banner ad

AT&T

1998

Google launches its search engine

Google

2000

Dot com crash: NASDAQ loses $5trn in 2 years

2005

First video uploaded to YouTube

0:00 2:20

2014

Number of websites exceeds

1 BILLION

2016

Worldwide e-commerce reaches almost 9% of total retail sales

The Web

What began as an information management project, "the web" is an invention that most of us can't imagine life without. In this retrospective article, Michael Dargue looks at the history of the web, chronicling the events and inventions of how it has changed our lives in the last 25 years.

By happy coincidence, the history of the web is a close fit for the 25-year timeline of our series of retrospective articles. Yet despite its short history, I found this a tough topic to tackle in a short article: it was hard to think of any facets of the modern world that the web has not touched somehow.

The Early Life of the Web

The web began life as a research project at CERN, the European physics research center. Sir Tim Berners-Lee secured funding for a research project on information management in 1989, and brought the web to life with the first server and browser in December 1990. The following year saw the first web servers outside of CERN and the web's first steps to becoming "world wide". Little did anyone realize how far-reaching this invention would become.

I first encountered the web two years later, in 1993. I was fortunate to be working for a firm that already had internet access and I compiled the Mosaic browser on my Unix workstation. Although Mosaic was not the first web browser, it was arguably the most successful in making the web accessible, having a graphical user interface and a (relatively!) simple installation.

Although rudimentary by today's standards, what was immediately apparent was the way in which the web transformed the organization of online information. In stark contrast to the rigid hierarchies that existed before the web (see for example, Usenet and Gopher), the web enabled an organic, decentralized mesh of information. These factors – and the decision by Berners-Lee to make his invention freely available – provided the foundations for rapid growth.

Growing Up in the 90s

Back in 1993, the web had very little content – only 623 websites according to one study [i]. These included some familiar sites such as Bloomberg, IMDB and Wired, however, the web was already a home for the irreverent and bizarre. Early examples included online comics, the ever-popular Darwin Awards and, in 1994, the Amazing FishCam (a webcam pointed at a fish tank).

By 1997, the number of websites had surpassed 600,000, doubling in size about every 4 months. As the web experienced this tremendous expansion, it was clear that users needed assistance with content discovery. It seems surprising now, but several efforts were made to catalog the growing web. For example, Yahoo! started out this way in 1995 as a hierarchical directory. Search engines also emerged at around the same time, with early examples including AltaVista, Excite and Lycos. It wasn't until 1998 that Google arrived on the scene.

The late 90s saw all sorts of companies rushing to get online and establish their web presence. For many companies, the web offered a new location for a shop window or brochure. Some, however, saw it as a new channel for commerce.

Going into Business

From the early days of the web, advertising was an important source of online revenue. The first banner ad appeared in 1994, promoting AT&T on the Hotwired website. Other sites followed suit and agencies and ad networks soon stepped in to aggregate this inventory and effectively monetize it. From an industry perspective, the late 90s was a time of rich innovation in online advertising; however, from a user perspective this was a period plagued by blinking banner ads, animated GIFs, pop-up windows and other distractions.

The frenetic online activity was only matched by the appetite of investors ploughing into the new digital sector. Looking back, it's easy to say that the valuation multiples were clearly unsupportable, but it was a shock to many when the dot com bubble burst. Over the space of two years – from March 2000 to October 2002 – the NASDAQ index lost $5 trillion in value and many firms hit the wall [ii].

The crash may have rocked investor confidence, but it did nothing to halt consumer

appetite for online consumption. Commerce followed advertising, and the web became an important sales channel in its own right. It's estimated that in 2016, worldwide retail e-commerce sales will hit $1.9 trillion, representing almost 9% of total retail sales [iii]. These figures are a testament to the trust that consumers now place in e-commerce. It took some years for consumers to get comfortable with submitting their bank details online, but once these fears were overcome, the positive factors of convenience, choice, and cost won out.

Giving Everyone a Voice

The next major evolution of the web was the rise of user-generated content : the ability for anyone to become a publisher rather than just a consumer. In the period from 2000 to 2005, a raft of new websites emerged including Facebook, Flickr, LinkedIn, Myspace, Wikipedia, WordPress, and YouTube. These new platforms (loosely termed Web 2.0) made it simple for non-technical users to upload and share content. The fact that we can all now share our photos, music, videos and blogs on a world stage is quite remarkable if you stop to think about it. But, perhaps unsurprisingly, online content is now awash with everything from cat photos to ice-bucket challenges and every meme in between.

Whilst easy to trivialize, these developments led to significantly more engagement in the web as a media channel. And as the web has grown in importance, so traditional media has faced a painful – and at times, sudden – decline. For example, the rise of online news outlets has seen newspaper circulations fall dramatically (in the UK, a decline of 40% since 1997) [iv]. In response, some titles have sought to build an online business (e.g. Financial Times, Wall Street Journal) whereas others have abandoned charging for their print editions and have instead switched to ad-funded model (London's Evening Standard).

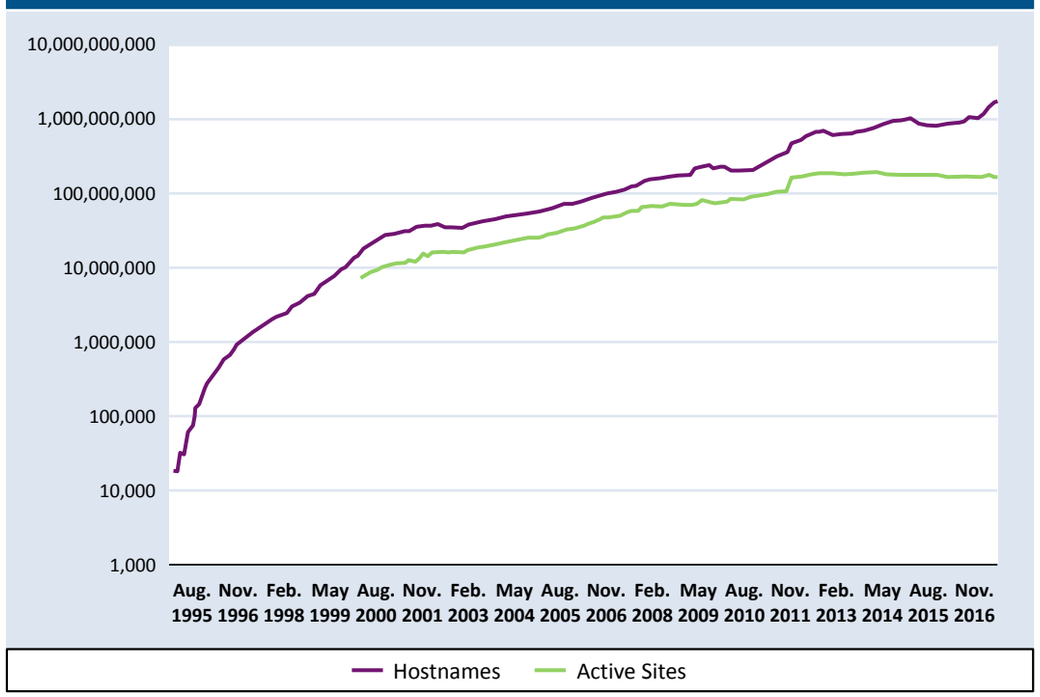
Linear TV has also been hard hit, as viewers have favored on-demand video streamed from the web. Some broadcasters have made a notable success of this but even so, they face new competition from web giants such as Netflix and YouTube.

Besides media, other sectors have witnessed the disruptive power of the web, for example Amazon in the case of retail and Expedia in travel booking. In many cases, new entrants used the speed, reach and economics of the web to undercut or outperform traditional business models. Elsewhere, firms have sought to disintermediate their neighbors in the value chain – brokers, agents and distributors – to reach their customers directly.

Communicating at Web-Scale

The web has also changed the way we communicate. The global reach of the web allows information and ideas to be shared faster and more widely than ever before, without editorial control and – for the most part – free of state censorship. Society and individuals are still adapting to this new world which promises greater transparency, yet at the same time, provides greater scope for hoaxes and misinformation. In many ways, we have found that the web can amplify traditional human communications, both good and bad.

Total Number of Websites, on a Logarithmic Scale[v]



The role of the web in inter-personal communications has been further solidified through the rise of the mobile web in the last decade. Mobile sites and apps for platforms such as Facebook, Twitter and Instagram have blended seamlessly with their

desktop counterparts, enabling users to engage in online conversations whilst on the go. In fact, in many countries, mobile usage has now outstripped desktop access as smartphones adoption has become widespread.

What's Next?

Looking back, it's incredible how far we have come in these 25 years: from a few text-based pages on Berners-Lee's NeXT computer to a global platform for communication, entertainment and commerce. Looking ahead, the web is so intertwined with business and society that it's hard to disentangle it from technological progress more generally. I expect to see more mobility, more intelligence and more machines in the next quarter-century. Where do you think the web will take us next? <>

Notes:

[i] Gray, Matthew. "Web Growth Summary". Massachusetts Institute of Technology.

[ii] Gaither, Chris and Chmielewski, Dawn C. LA Times: "Fears of Dot-Com Crash, Version 2.0" July 2016.

[iii] eMarketer: "Worldwide Retail Ecommerce Sales Will Reach $1.915 Trillion This Year." August 2016.

[iv] Audit Bureau of Circulations. Wikipedia: "List of newspapers in the United Kingdom by circulation."

[v] Netcraft, January 2017 Web Server Survey.

Acknowledgments

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Cartesian® is a specialist provider of consulting services and managed solutions to leaders in the global telecoms, media and technology industries. For 25 years, we have advised clients worldwide in strategy development and assisted them in execution against their goals. Our unique portfolio of consulting services and managed solutions are tailored to the specific challenges faced by executives in these fast-moving industries. Combining strategic thinking, robust analytics, and practical experience, Cartesian delivers superior results.

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