The internet: Everything you ever need to know

In spite of all the answers the internet has given us, its full potential to transform our lives remains the great unknown. Here are the nine key steps to understanding the most powerful tool of our age – and where it’s taking us

A funny thing happened to us on the way to the future. The internet went from being something exotic to being boring utility, like mains electricity or running water – and we never really noticed. So we wound up being totally dependent on a system about which we are terminally incurious. You think I exaggerate about the dependence? Well, just ask Estonia, one of the most internet-dependent countries on the planet, which in 2007 was more or less shut down for two weeks by a sustained attack on its network infrastructure. Or imagine what it would be like if, one day, you suddenly found yourself unable to book flights, transfer funds from your bank account, check bus timetables, send email, search Google, call your family using Skype, buy music from Apple or books from Amazon, buy or sell stuff on eBay, watch clips on YouTube or BBC programmes on the iPlayer – or do the 1,001 other things that have become as natural as breathing.

The internet has quietly infiltrated our lives, and yet we seem to be remarkably unreflective about it. That’s not because we’re short of information about the network; on the contrary, we’re awash with the stuff. It’s just that we don’t know what it all means. We’re in the state once described by that great scholar of cyberspace, Manuel Castells, as “informed bewilderment”.

Mainstream media don’t exactly help here, because much – if not most – media coverage of the net is negative. It may be essential for our kids’ education, they concede, but it’s riddled with online predators, seeking children to “groom” for abuse. Google is supposedly “making us stupid” and shattering our concentration into the bargain. It’s also allegedly leading to an epidemic of plagiarism. File sharing is destroying music, online news is killing newspapers, and Amazon is killing bookshops. The network is making a mockery of legal injunctions and the web is full of lies, distortions and half-truths. Social networking fuels the growth of vindictive “flash mobs” which ambush innocent columnists such as Jan Moir. And so on.

All of which might lead a detached observer to ask: if the internet is such a disaster, how...
come 27% of the world's population (or about 1.8 billion people) use it happily every day, while billions more are desperate to get access to it?

So how might we go about getting a more balanced view of the net? What would you really need to know to understand the internet phenomenon? Having thought about it for a while, my conclusion is that all you need is a smallish number of big ideas, which, taken together, sharply reduce the bewilderment of which Castells writes so eloquently.

But how many ideas? In 1956, the psychologist George Miller published a famous paper in the journal *Psychological Review*. Its title was "The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information" and in it Miller set out to summarise some earlier experiments which attempted to measure the limits of people's short-term memory. In each case he reported that the effective "channel capacity" lay between five and nine choices. Miller did not draw any firm conclusions from this, however, and contented himself by merely conjecturing that "the recurring sevens might represent something deep and profound or be just coincidence". And that, he probably thought, was that.

But Miller had underestimated the appetite of popular culture for anything with the word "magical" in the title. Instead of being known as a mere aggregator of research results, Miller found himself identified as a kind of sage — a discoverer of a profound truth about human nature. "My problem," he wrote, "is that I have been persecuted by an integer. For seven years this number has followed me around, has intruded in my most private data, and has assaulted me from the pages of our most public journals... Either there really is something unusual about the number or else I am suffering from delusions of persecution."

But in fact, the basic idea that emerges from Miller's 1956 paper seems to have stood the test of time. The idea is that our short-term memory can only hold between five and nine "chunks" of information at any given moment (here a chunk is defined as a "meaningful unit"). So, when trying to decide how many big ideas about the internet would be meaningful for most readers, it seemed sensible to settle for a magical total of nine. So here they are.

1 TAKE THE LONG VIEW

The strange thing about living through a revolution is that it's very difficult to see what's going on. Imagine what it must have been like being a resident of St Petersburg in 1917, in the months before Lenin and the Bolsheviks finally seized power. It's clear that momentous events are afoot; there are all kinds of conflicting rumours and theories, but nobody knows how things will pan out. Only with the benefit of hindsight will we get a clear idea of what was going on. But the clarity that hindsight bestows is also misleading, because it understates how confusing things appeared to people at the time.

So it is with us now. We're living through a radical transformation of our communications environment. Since we don't have the benefit of hindsight, we don't really know where it's taking us. And one thing we've learned from the history of communications technology is that people tend to overestimate the short-term impact of new technologies — and to underestimate their long-term implications.

We see this all around us at the moment, as would-be savants, commentators, writers, consultants and visionaries tout their personal interpretations of what the internet means for business, publishing, retailing, education, politics and the future of civilisation as we know it. Often, these interpretations are compressed into vivid slogans, memes or aphorisms: information "wants to be free"; the "long tail" is the future of retailing; "Facebook just seized control of the internet", and so on. These kinds of slogans are really just short-term extrapolations from yesterday's or today's experience. They tell us little about where the revolution we're currently living through is heading. The question is: can we do any better — without falling into the trap of feigning omniscience?

Here's a radical idea: why not see if there's anything to be learned from history? Because mankind has lived through an earlier transformation in its communications
environment, brought about by the invention of printing by movable type. This technology changed the world — indeed, it shaped the cultural environment in which most of us grew up. And the great thing about it, from the point of view of this essay, is that we can view it with the benefit of hindsight. We know what happened.

A thought experiment

So let's conduct what the Germans call a *Gedankenexperiment* — a thought experiment. Imagine that the net represents a similar kind of transformation in our communications environment to that wrought by printing. What would we learn from such an experiment?

The first printed bibles emerged in 1455 from the press created by Johannes Gutenberg in the German city of Mainz. Now, imagine that the year is 1472 — ie 17 years after 1455. Imagine, further, that you're the medieval equivalent of a Mori pollster, standing on the bridge in Mainz with a clipboard in your hand and asking pedestrians a few questions. Here's question four: On a scale of one to five, where one indicates "Not at all likely" and five indicates "Very likely", how likely do you think it is that Herr Gutenberg's invention will:

(a) Undermine the authority of the Catholic church?
(b) Power the Reformation?
(c) Enable the rise of modern science?
(d) Create entirely new social classes and professions?
(e) Change our conceptions of "childhood" as a protected early period in a person's life?

On a scale of one to five! You have only to ask the questions to realise the fatuity of the idea. Printing did indeed have all of these effects, but there was no way that anyone in 1472, in Mainz (or anywhere else for that matter) could have known how profound its impact would be.

I'm writing this in 2010, which is 17 years since the web went mainstream. If I'm right about the net effecting a transformation in our communications environment comparable to that wrought by Gutenberg, then it's patently absurd for me (or anyone else) to pretend to know what its long-term impact will be. The honest answer is that we simply don't know.

The trouble is, though, that everybody affected by the net is demanding an answer right now. Print journalists and their employers want to know what's going to happen to their industry. Likewise the music business, publishers, television networks, radio stations, government departments, travel agents, universities, telcos, airlines, libraries and lots of others. The sad truth is that they will all have to learn to be patient. And, for some of them, by the time we know the answers to their questions, it will be too late.

2 THE WEB ISN'T THE NET

The most common — and still surprisingly widespread — misconception is that the internet and the web are the same thing. They're not. A good way to understand this is via a railway analogy. Think of the internet as the tracks and signalling, the infrastructure on which everything runs. In a railway network, different kinds of traffic run on the infrastructure — high-speed express trains, slow stopping trains, commuter trains, freight trains and (sometimes) specialist maintenance and repair trains.

On the internet, web pages are only one of the many kinds of traffic that run on its virtual tracks. Other types of traffic include music files being exchanged via peer-to-peer networking, or from the iTunes store; movie files travelling via BitTorrent; software updates; email; instant messages; phone conversations via Skype and other VoIP (internet telephony) services; streaming video and audio; and other stuff too arcane to mention.
And (here's the important bit) there will undoubtedly be other kinds of traffic, stuff we can't possibly have dreamed of yet, running on the internet in 10 years' time.

So the thing to remember is this: the web is huge and very important, but it's just one of the many things that run on the internet. The net is much bigger and far more important than anything that travels on it.

Understand this simple distinction and you're halfway to wisdom.

3 DISRUPTION IS A FEATURE, NOT A BUG

One of the things that most baffles (and troubles) people about the net is its capacity for disruption. One moment you've got a stable, profitable business – say, as the CEO of a music label; the next minute your industry is struggling for survival, and you're paying a king's ransom to intellectual property lawyers in a losing struggle to stem the tide. Or you're a newspaper group, wondering how a solid revenue stream from classified ads could suddenly have vaporised; or a university librarian wondering why students use only Google nowadays. How can this stuff happen? And how does it happen so fast?

The answer lies deep in the network's architecture. When it was being created in the 1970s, Vint Cerf and Robert Kahn, the lead designers, were faced with two difficult tasks: how to design a system that seamlessly links lots of other networks, and how to design a network that is future-proof. The answer they came up with was breathtakingly simple. It was based on two axioms. Firstly, there should be no central ownership or control – no institution which would decide who could join or what the network could be used for. Secondly, the network should not be optimised for any particular application. This led to the idea of a "simple" network that did only one thing – take in data packets at one end and do its best to deliver them to their destinations. The network would be neutral as to the content of those packets – they could be fragments of email, porn videos, phone conversations, images... The network didn't care, and would treat them all equally.

By implementing these twin protocols, Vint Cerf and Robert Kahn created what was essentially a global machine for springing surprises. The implication of their design was that if you had an idea that could be implemented using data packets, then the internet would do it for you, no questions asked. And you didn't have to ask anyone's permission.

The explosion of creativity – in the form of disruptive applications – that the world has seen since the network emerged in the 1980s may have taken a lot of institutions and industries by surprise, but it was predictable, given the architecture. There are a lot of smart programmers in the world, and the net provided them with a perfect launch pad for springing surprises. What kinds of surprises? Well, the web itself. It was largely the creation of a single individual – Tim Berners-Lee, who in 1991 put the code on an internet server without having to ask anyone's permission.

Ten years after Berners-Lee started work, a disaffected, music-loving teenager named Shawn Fanning spent six months writing software for sharing music files and, in 1999, put his little surprise on an internet server. He called it Napster and it acquired over 60 million delighted users before the music industry managed to shut it down. But by that time the file-sharing genie was out of the bottle.

While all this was going on, plenty of equally smart programmers were incubating more sinister surprises, in the shape of a plague of spam, viruses, worms and other security "exploits" which they have been able to unleash over a network which doesn't care what’s in your data packets. The potential dangers of this "malware" explosion are alarming. For example, mysterious groups have assembled "botnets" (made up of millions of covertly compromised, networked PCs) which could be used to launch massive, co-ordinated attacks that could conceivably bring down the network infrastructure of entire industries, or perhaps even countries. So far, with the exception of Estonia in 2007, we haven't seen such an attack, but the fear is that it will eventually come, and it will be the net's own version of 9/11.
The internet’s disruptiveness is a consequence of its technical DNA. In programmers’ parlance, it’s a feature, not a bug – ie an intentional facility, not a mistake. And it’s difficult to see how we could disable the network’s facility for generating unpleasant surprises without also disabling the other forms of creativity it engenders.

### 4 THINK ECOLOGY, NOT ECONOMICS

As an analytical framework, economics can come unstuck when dealing with the net. Because while economics is the study of the allocation of scarce resources, the online world is distinguished by abundance. Similarly, ecology (the study of natural systems) specialises in abundance, and it can be useful to look at what's happening in the media through the eyes of an ecologist.

Since the web went mainstream in 1993, our media "ecosystem", if you like, has become immeasurably more complex. The old, industrialised, mass-media ecosystem was characterised by declining rates of growth; relatively small numbers of powerful, profitable, slow-moving publishers and broadcasters; mass audiences consisting mainly of passive consumers of centrally produced content; relatively few communication channels, and a slow pace of change. The new ecosystem is expanding rapidly: it has millions of publishers; billions of active, web-savvy, highly informed readers, listeners and viewers; innumerable communication channels, and a dizzying rate of change.

To an ecologist, this looks like an ecosystem whose biodiversity has expanded radically. It’s as if a world in which large organisms like dinosaurs (think Time Warner, Encyclopaedia Britannica) had trudged slowly across the landscape exchanging information in large, discrete units, but life was now morphing into an ecosystem in which billions of smaller species consume, transform, aggregate or break down and exchange information goods in much smaller units – and in which new gigantic life-forms (think Google, Facebook) are emerging. In the natural world, increased biodiversity is closely correlated with higher whole-system productivity – ie the rate at which energy and material inputs are translated into growth. Could it be that this is also happening in the information sphere? And if it is, who will benefit in the long term?

### 5 COMPLEXITY IS THE NEW REALITY

Even if you don’t accept the ecological metaphor, there's no doubt that our emerging information environment is more complex – in terms of numbers of participants, the density of interactions between them, and the pace of change – than anything that has gone before. This complexity is not an aberration or something to be wished away: it’s the new reality, and one that we have to address. This is a challenge, for several reasons. First, the behaviour of complex systems is often difficult to understand and even harder to predict. Second, and more importantly, our collective mindsets in industry and government are not well adapted for dealing with complexity. Traditionally, organisations have tried to deal with the problem by reducing complexity – acquiring competitors, locking in customers, producing standardised products and services, etc. These strategies are unlikely to work in our emerging environment, where intelligence, agility, responsiveness and a willingness to experiment (and fail) provide better strategies for dealing with what the networked environment will throw at you.

### 6 THE NETWORK IS NOW THE COMPUTER

For baby-boomers, a computer was a standalone PC running Microsoft software. Eventually, these devices were networked, first locally (via office networks) and then globally (via the internet). But as broadband connections to the net became commonplace, something strange happened: if you had a fast enough connection to the network, you became less concerned about the precise location of either your stored data or the processor that was performing computational tasks for you. And these tasks became easier to do. First, the companies (Yahoo, Google, Microsoft) who provided search also began to offer "webmail" – email provided via programs that ran not on your...
PC but on servers in the internet "cloud". Then Google offered word-processing, spreadsheets, slide-making and other "office"-type services over the network. And so on.

Here was a transition from a world in which the PC really was the computer, to one in which the network is effectively the computer. It has led to the emergence of "cloud computing" – a technology in which we use simple devices (mobile phones, low-power laptops or tablets) to access computing services that are provided by powerful servers somewhere on the net. This switch to computing as a utility rather than a service that you provide with your own equipment has profound implications for privacy, security and economic development – and public perceptions are lagging way behind the pace of development. What happens to your family's photo collection if it's held in the cloud and your password goes to the grave with you? And what about your documents and emails – all likewise stored in the cloud on someone else's server? Or your "reputation" on eBay? Everywhere one looks, the transition to cloud computing has profound implications, because it makes us more and more dependent on the net. And yet we're sleepwalking into this brave new world.

7 THE WEB IS CHANGING

Once upon a time, the web was merely a publication medium, in which publishers (professional or amateur) uploaded passive web pages to servers. For many people in the media business, that's still their mental model of the web. But in fact, the web has gone through at least three phases of evolution – from the original web 1.0, to the web 2.0 of "small pieces, loosely joined" (social networking, mashups, webmail, and so on) and is now heading towards some kind of web 3.0 – a global platform based on Tim Berners-Lee's idea of the 'semantic web' in which web pages will contain enough metadata about their content to enable software to make informed judgements about their relevance and function. If we are to understand the web as it is, rather than as it once was, we need more realistic mental models of it. Above all, we need to remember that it's no longer just a publication medium.

8 HUXLEY AND ORWELL ARE THE BOOKENDS OF OUR FUTURE

Many years ago, the cultural critic Neil Postman, one of the 20th century's most perceptive critics of technology, predicted that the insights of two writers would, like a pair of bookends, bracket our future. Aldous Huxley believed that we would be destroyed by the things we love, while George Orwell thought we would be destroyed by the things we fear.

Postman was writing before the internet became such a force in our societies, but I believe he got it right. On the one (Huxleyan) hand, the net has been a profoundly liberating influence in our lives – creating endless opportunities for information, entertainment, pleasure, delight, communication, and apparently effortless consumption, to the point where it has acquired quasi-addictive power, especially over younger generations. One can calibrate the extent of the impact by the growing levels of concern among teachers, governments and politicians. "Is Google making us stupid?" was the title of one of the most cited articles in Atlantic magazine in 2008. It was written by Nicholas Carr, a prominent blogger and author, and raised the question of whether permanent access to networked information (not just Google) is turning us into restless, shallow thinkers with shorter attention spans. (According to Nielsen, a market research firm, the average time spent viewing a web page is 56 seconds.) Other critics are worried that incessant internet use is actually rewiring our brains.

On the other (Orwellian) hand, the internet is the nearest thing to a perfect surveillance machine the world has ever seen. Everything you do on the net is logged – every email you send, every website you visit, every file you download, every search you conduct is recorded and filed somewhere, either on the servers of your internet service provider or...
of the cloud services that you access. As a tool for a totalitarian government interested in the behaviour, social activities and thought-process of its subjects, the internet is just about perfect.

9 OUR INTELLECTUAL PROPERTY REGIME IS NO LONGER FIT FOR PURPOSE

In the analogue world, copying was difficult and degenerative (ie copies of copies became progressively worse than the original). In the digital world, copying is effortless and perfect. In fact, copying is to computers as breathing is to living organisms, inasmuch as all computational operations involve it. When you view a web page, for example, a copy of the page is loaded into the video memory of your computer (or phone, or iPad) before the device can display it on the screen. So you can't even look at something on the web without (unknowingly) making a copy of it.

Since our current intellectual property regime was conceived in an era when copying was difficult and imperfect, it's not surprising that it seems increasingly out of sync with the networked world. To make matters worse (or better, depending on your point of view), digital technology has provided internet users with software tools which make it trivially easy to copy, edit, remix and publish anything that is available in digital form – which means nearly everything, nowadays. As a result, millions of people have become "publishers" in the sense that their creations are globally published on platforms such as Blogger, Flickr and YouTube. So everywhere one looks, one finds things that infringe copyright in one way or another.

This is a disagreeable but inescapable fact – as inescapable in its way as the fact that young adults tend to drink too much alcohol. The only way to stop copying is to shut down the net. There's nothing wrong with intellectual property (or alcohol), per se, but our copyright laws are now so laughably out of touch with reality that they are falling into disrepute. They urgently need reforming to make them relevant to digital circumstances. The problem is that none of our legislators seems to understand this, so it won't happen any time soon.

Postscript

It would be ridiculous to pretend that these nine ideas encapsulate everything that there is to be known about the net. But they do provide a framework for seeing the phenomenon "in the round", as it were, and might even serve as an antidote to the fevered extrapolation that often passes for commentary on developments in cyberspace. The sad fact is that if there is a "truth" about the internet, it's rather prosaic: to almost every big question about the network's long-term implications the only rational answer is the one famously given by Mao Zedong's foreign minister, Zhou Enlai, when asked about the significance of the French Revolution: "It's too early to say." It is.

John Naughton is professor of the public understanding of technology at the Open University. He is currently working on a book about the internet phenomenon.
The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data. Thanks to the arrival of super-cheap computer chips and the ubiquity of wireless networks, it's possible to turn anything, from something as small as a pill to something as big as an aeroplane, into a part of the IoT. What is 5G? Everything you need to know about the new wireless revolution. It's a capital improvement project the size of the entire planet, replacing one wireless architecture created this century with another one that aims to lower energy consumption and maintenance costs. Read More. As you'll see, some things just need to be talked through. We hope you benefit, and if you do, please click the heart at the bottom to help others find it too! Enjoy!

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You Don’t Know a Protocol’s Battery life Until It's Fully Developed.

John Naughton's feature in today's Observer, “The internet: Everything you ever need to know,” is a fantastic read and a marvel of economy, managing to pack nine very big ideas into 15 minutes' reading. This is the kind of primer you want to slide under your boss's door. 4 think ecology, not economics. As an analytical framework, economics can come unstuck when dealing with the net. Because while economics is the study of the allocation of scarce resources, the online world is distinguished by abundance. Similarly, ecology (the study of natural systems) specialise