THE SYSTEMS INNOVATOR

WHY SUCCESSFUL INNOVATION GOES BEYOND PRODUCTS

Charlie Leadbeater

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1 THE ART OF ARRIVING LATE

Steve Jobs was often late. Apple has not always been first to market with cutting edge technology. Often it turned up when the party had got going but before it was in full swing. Apple brought some of its key products to market only when it knew it could wrap around them a supportive system which would deliver content and services to customers with one hand and with the other collect all their credit card details.[1]

The Apple that started making computers to sit on desktops was a product company. The Apple that has become the most valuable company in the world does something different: it creates products that are entry points to systems. It is a systems innovator.

The shift from product to system began with the Apple iPod. The iPod was not the world's first portable digital audio player. That was the MPMan, made by a Korean company, SaeHan Information Systems, which was launched in the US in 1998. When Apple arrived three years later with the iPod, 248,000 MP3 players had already been sold in the US.

The trouble with these early MP3 players was that a good product was not enough. Digital music stores had to be created so consumers could find what they were looking for online. Then they had to download them to a computer but that required a high-speed broadband connection which in those days was still rare. Once a consumer had the music on their computer they then had to transfer to the MP3 player. The difficulties were not just technical. The music industry, in the midst of the Napster rebellion and rampant file sharing, was fearful of losing its control over its content.

The iPod succeed because it was more than an elegantly styled and easy to use product. It arrived at just the right time, when Apple could also bring into being a new system for buying, playing and sharing music. Many of the innovations in this system did not come from Apple. The MP3 file format was developed in a German technical university. Broadband connections were provided by telecommunications companies. Apple's was not the first online music store but it was the first that had enough content and was easy enough to use to make buying music online attractive. In 2004 portable CD players still outsold MP3 players. As Apple's new system came into place between 2004 and 2005 iPod sales rocketed 616 per cent. The iPod took off when a good product became part of a larger commercial and cultural system for providing music. Not only was Apple providing a product and a system – content, services, software – it was also helping us as consumers to create and adopt the new lifestyles made possible by digital technologies. In a sense Apple was teaching us how to be modern; through its products and systems we learned new ways to behave. Mass behaviour change is invariably the other major ingredient in systems change.

From 2007 Apple applied the same strategy to the smartphone market to devastating effect. Not only was Jobs once again late, his product, the Apple iphone was sub-standard: it had a poor camera; could not record video; often dropped calls; worked only on 2G networks; had to be bought, at a premium from an authorised network. Apple warned its users that any attempts to install non-Apple software on the phone would void the warranty. The iPhone was going to be a closed product. Apple insisted its phone buyers use iTunes as the interface to register their phones. That way Apple carried over its music buyers, complete with their credit cards.

Then in 2008 after hackers (frustrated consumers) continued to develop non-approved applications Apple released a software development kit for the iPhone. In July that year the company launched the App Store, as a spin off from iTunes, with 500 third party applications. Six months later there had been five million downloads. In 2011 Apple celebrated the ten billionth app download. The wide array apps, provided by third party developers, meant that the basic, featureless phone could be constantly refreshed at relatively low cost. Apple swept aside the industry's established leader Nokia which based its strategy on the range and sophistication of its many phones. Apple instead had just one phone, linked to a vast system for creating new content and applications.

Apple often came late to the party, with products that were not cutting edge and yet still rose to command the digital economy in the first decade of the century. Apple pulled off this trick because it followed – perhaps invented – a different set of rules, the first of which is that: products are only as valuable as the systems they are part of. The future will belong to companies that assemble whole systems – content, services, software, finance – around their products and as a result help to bring about mass change in behaviour.

Of course this does not mean that product innovators are dead. Companies like Dyson make fantastically successful products, from fans to hand dryers and vacuum cleaners. But as our economies become ever more networked, information rich and organised with the help of digital technologies, more of the way we work and live, create value and innovate will shift towards the Apple approach: systems matter more than individual products.

This paper is an attempt to explain why systems innovation will become the most important focus for companies and governments, cities and entire societies. In the last decade there has been a growing focus on innovation in products and services as a source of competitive advantage.[2] In the next decades the focus will shift towards the innovation of new kinds of systems.

2 THE NEED FOR SYSTEMS INNOVATION

Systems loom large in our lives. Modern, urban life is unimaginable without systems. When they break down our lives are thrown into chaos: witness the turmoil created by the collapse of India's electricity grid on several occasions in the summer of 2012 and the failure of NatWest bank's computerised payment system. Few transactions in a shop can be completed without the question: 'Have we got you on our system?' A conversation with a call centre can never really get started unless 'the system' the person is working on is up to speed.

Each day most of us rely on energy systems to light and heat our homes; transport systems to take us from home to work and back again; information and communications systems to deliver news, texts, email, social media; environmental systems to remove our waste; legal and technical systems to allow us to get our work done; systems of production and distribution to provide us with goods in shops and financial systems to allow us to buy them with the swipe of a card. In cities we take it for granted that we should be able to find an ATM machine that will dispense cash wherever we are in the world, so long as we can put in a card with the rights details.

There will be more systems of this kind. The rise of information and communication systems – cloud computing, mobile devices, objects loaded with RfID tabs – means that our every action will generate information to be logged on systems. Many commercial decisions, from the shares that investors buy to the stock that shops reorder, are made with the help of software algorithms. We rage against systems for being cumbersome, unfeeling and dumb. We blame our misfortunes on 'the system' as an abstract force in our lives. But systems are rarely just our enemies. When a system breaks down it does not take long for someone to complain: 'If only there were a system.' Most of the planet lives in cities and modern, urban people can only live together on a mass scale in a civil way if they are supported by many unseen and increasingly interconnected systems. Systems help to make life more efficient, seamless and productive.

Yet many of these systems we rely upon are in deep trouble. The financial crisis was caused by systemic failings in an increasingly interconnected and complex banking system. Our resource hungry systems of energy, transport and production need to be redesigned to minimise waste and prevent catastrophic climate change. Our systems of health and social care need redesigning to cope with the challenges of ageing populations and the rise of long-term conditions such as diabetes and obesity. There is a growing consensus that the post-war welfare state needs to be designed to reduce long-term dependency on benefits. Political systems are too detached from and distrusted by citizens.[3]

The very features that make systems so powerful – the way they bring together different components to achieve a purpose – also make them difficult to change. Setting out to change an entire system, in all its complexity, often seems hopelessly ambitious. The result is that would be systems reformers do little more than tinker at the edges, changing a part of a system but leaving the rest untouched.

In the emerging economies of the developing world it is a different story. There fast growing cities are contemplating the creation of new systems on a vast scale for housing, transport, communications, education and health. These cities have the opportunity to create new generations of systems, which are configured to be more environmentally sustainable.[4]

Working in the favour of would–be system innovators are new technologies, from digital systems to biotechnology, which increasingly overlay every aspect of our lives. In the past decade we have embraced vast new systems for creating, sharing, processing and analysing information from the Internet and the world wide web, through to new generations of mobile phones and social media to the possibilities of cloud computing, the semantic web and the Internet of things. These digital platforms could allow us to create more distributed, networked systems to achieve feats of co–ordination previously associated with large hierarchical organisations. According to some futurists we stand on the verge of creating entirely new systems and possibly even civilisations, as human intelligence becomes inextricable from computer intelligence, which is set to grow exponentially.[5]

So systems are a vital underpinning for modern life, especially in cities. Many of the systems we rely on in the developed world seem in need of far reaching overhaul. The developing world will need new systems on a vast scale over the next few decades. How should innovators go about trying to use these new technologies to reform, adapt and create better systems?

3 SCHOOLS, CONTAINERS AND TWEETS

A system is a set of elements that are brought together, sometimes by design but often through evolution, to achieve a purpose.[6] A football team can be organised into a system (the 4–4–2 formation) but so too can the way we dispense welfare (the benefits systems) and justice (the criminal justice system.) Railways depend on systems as does the Catholic church. We depend on material systems to provide us with energy and to take away our waste; industrial systems to turn raw materials into products; the bureaucratic and legal systems of the modern state, for collecting taxes and distributing benefits; information and communication systems to connect us together through post and television, mobile phones and the Internet; symbolic systems of music and culture, branding and advertising to help shape the meaning of our lives. Modern life has been made possible by the rise of these systems. A system can be a method: a way to learn like the Susuki method for learning the violin.[7] But the systems we are interested in are not just methods: they are a set of elements that are brought together, sometimes by design but often through evolution, to achieve a purpose. Though systems share family resemblances they also have their own personalities. We now live with systems inherited from different eras, with quite different models of organisation. Take education, containerisation and social media as examples.

Education

The US started the 19th century with children being educated in church basements, private houses and one–room rural schools. In the UK in the 1830s it was easy for a reasonably literate man to set up a school in his front room and attract fee–paying pupils, while unmarried women created ‘dame schools’ in their homes and gardens. Most elementary education was completely unregulated. By the end of the century, education had become a system. Many of the features of that system persist till today.

The roots of the modern school system started with the growth of religious Sunday schools which taught reading to promote Bible study. The first purpose built British Sunday School was set up in 1802 in Hoxton, east London designed to accommodate 1,000 children. By 1851 more than two million children were enrolled in Sunday schools; many carried on working during the week.

A major step towards the creation of a more systematic primary education system in the UK was taken by two rival clerics Dr Andrew Bell, an Anglican and Dr Joseph Lancaster, a dissenting Protestant, who created a monitorial system in which older boys taught small groups of young boys, allowing a single master to control the education of hundreds of boys in a large space divided into separate class rooms. Contemporaries compared Bell and Lancaster’s system to the steam engine, powering a far more efficient form of education. By the mid 19th century the Newcastle Commission found that schooling of some kind was the norm for most of the young in England. The Elementary Education Act of 1870 paved the way for the creation of Board schools, which Sherlock Holmes described as *“beacons of the future.”* By the late 19th century it was widely accepted in the UK – and much of the rest of Europe – that education should be for all, at least to an elementary standard, and that required a system of schools. As Richard Aldrich, the pre–eminent historian of English education put it: *“Basic elementary education was redefined in the years 1870–1900 as a compulsory, age–specific, professional teacher directed, school–based exercise aimed at the mastery of prescribed school subjects grouped around a central core of basic literacy.”*[8] By 1900, compulsory elementary education was established in most of Europe (Belgium the laggard followed suit in 1920.) In Europe the proportion of children attending school went from about 25 per cent in 1870 to 75 per cent in 1900. What had started as a sporadic service in informal, private and religious settings had become a system, involving new products and practices, services and methods, buildings and infrastructure, behaviours and norms.

Education as schooling has delivered many benefits, from higher productivity and earnings, to social integration and national pride. Many countries in the developing world are still investing in school systems heavily influenced by this Victorian model. Those that have developed school systems are invariably seeking to reform them. Meanwhile new players are starting to enter education with alternative offers and even alternative systems: the massive growth of low–cost private education in the developing world and online, digital and distance learning, such as massive, open online courses which attract thousands of students. Yet education systems are difficult to budge. They still bear the hallmarks of the expanding state of the industrialising 19th century.

As David Tyack and Larry Cuban put it in their history of American schooling: *"The basic grammar of schooling, like the shape of classrooms, has remained remarkably stable over the decades. Little has changed in the ways that schools divide time and space, classify students and allocate them to classes, splinter knowledge into 'subjects' and award grades and credits as evidence of learning."*[9]

The education reformers of the 19th century created a new system out of fragments created by social entrepreneurs. The rise of containerisation in the 20th century is the story of how an old system was challenged and then displaced by a new one.

Containerisation

On 1 May, 1956, the Ideal X, a nondescript tanker, sailed into Houston harbour carrying a cargo that changed the world forever. The Ideal X was the first ship designed to carry containers. The 58 containers on that first voyage were not in themselves a revolution. That would come from making them a system: containerisation. In the following three decades containerisation would became a highly automated way to ship large quantities of freight at very low cost, seamlessly transferring loads to and from trucks, to railways and ships. That first journey hinted at the scale of the savings to come. In 1956 it would have cost about $5.8 per ton to carry a mixed load of loose cargo in barrels, sacks, pallets and crates on a medium–sized freighter. On the Ideal X the cost was $0.15 cents per ton.[10]

Before the container arrived transporting cargo was very expensive. A US government study in 1961 found that shipping costs accounted for 10 per cent – 12 per cent of the value of US exports and imports. The costs of moving freight were so high that it did not make sense to ship goods – like air conditioning units, microwaves, cars and trainers – half way around the world. The biggest part of those transport cost were moving goods from land to ship and back to land again.

Ships generally carried mixed loads made up of different goods – boxes of food, steel drums of cleaning materials, cotton in bales, machine tool parts on pallets, furniture crated up. Loading these mixed loads was a time consuming and skilled job. Most ports were close to manufacturing industries which themselves were in large cities, such as New York and London. Large bodies of men would drive, drag, push and pull cargo into and out of warehouses next to docks, often using little more than a hook. One gang of longshoremen on the dockside would load a pallet, which would be winched into one of the three or four hatches on a ship; another gang on board would unload the pallet and pack its contents into the hold. No two loads were the same. Each ship was like a giant three–dimensional jigsaw puzzle. Cargo was frequently damaged, lost and stolen. At the other end, the process would be completed in reverse. A ship could not be reloaded until everything had been taken off. Ships spent half their time in port.

Containerisation, by contrast, is a highly efficient but rather soulless system for shipping goods as securely and seamlessly as possible at low cost. Container ports tend not to be close to the heart of a city – Seattle is an exception – but on their edge, close to transport networks, ready to whisk the cargo away as fast as possible. The chaotic and casual work of the docks has been turned into something akin to working in a factory, operating a computer–controlled machine.

This revolution was started by a maverick entrepreneur Malcolm McLean who put the Ideal X to sea, with homemade containers, that were unloaded by second–hand cranes. But McLean's invention was turned into a full–blooded system only by many others playing a role. Another shipping company, the highly methodical Matson, refined the basic container adding twist locks on the corners so containers could be interchangeable and stacked safely. The bewildering array of containers that emerged in the early years were reduced to a standardised design. New generations of cranes were installed which made container ports 40 times more productive than the traditional docks. Specially designed container ships could be unloaded so fast that they spent just 10 per cent of their time in port. New container terminals were built, like Port Elizabeth, on marshland in New Jersey and at the once obscure port of Felixstowe in the east of England. By 1966 a single longshore gang operating at Port Elizabeth with one crane could handle as much as ten gangs using traditional methods. Loading container cargo cost $2.00 per ton at Port Elizabeth, compared to $16.00 for mixed freight. Closing the old docks in the city heart and changing working practices involved widespread redundancies and bitter industrial conflict.

Containerisation was not just a way to get goods onto and off ships economically. It became a new way to get freight from its origin to its destination. That meant that every part of the system – ports, ships, cranes, storage facilities, trucks, trains – would support a seamless flow. The big changes came when customers – the manufacturers, shippers and retailers – worked out how to make the most of this system and started redesigning their own production and buying activities to exploit the advantages the system offered. Shippers started buying services in a spot market. Manufacturers adopted just–in–time production techniques relying on far flung networks partly because the container system meant it made economic sense. In 1956 the world was full of small manufacturers, selling goods into local markets, protected by the knowledge that it would cost a lot for someone from outside the area to break into their market; by the end of the 20th century purely local producers had virtually disappeared.

Between the 1980s and the end of the century, more than $200 billion was invested in the creation of this system of ships, cranes, ports, trucks. The largest modern vessels carry 4,000 containers. Many of the companies that turned containerisation into a system were not involved at the outset: they were not radical innovators but system builders. Of the 20 ports handling the largest numbers of containers in 2003, seven had seen little container traffic in 1990 and three had not even existed. Maersk which accounts for a sixth of the world's container fleet, only built its first container ship in 1973.

Containerisation is several overlapping systems that have been brought together: a physical system for transporting cargo around in containers; a production system for making and distributing goods to be put in the containers; information and logistics systems to track the movement of goods through the system; legal and administrative systems which allow import and export; economic and financial systems to channel payments from consumers, to retailers, distributors, shippers and manufacturers. Almost every time we buy a product – a pair of trainers, spectacles, a television – that has travelled from outside our home market, we depend on this dense web of interconnected systems without even thinking about it.

Containerisation is a classic example of a heavy–duty, industrial system of the second half of the 20th century. The systems currently being created with digital technologies are different again.

Social media platforms

All entrepreneurship turns on who makes the right bet in a dispute about what consumers will do and where profits lie. In 2006, Evan Williams and Jack Dorsey made what seemed to many an extraordinary bet: that people would want to broadcast to the world using short messages of less than 140 characters, which would be a cross between a blog post and an SMS. Twitter was greeted with widespread scepticism when it was launched. Few could see the point. Yet Williams and Dorsey were proved right, in spectacular terms. By October 2012, 140 million active users were sending 340 million tweets a day. Twitter played a significant role in publicising and mobilising people in some of the revolts that made up the Arab Spring that year. In just a few years Twitter has become a global system for people exchanging information. Yet even if this was the founders' ambition they never had a detailed plan for how to achieve it. Twitter is an example of a system which has grown almost like bubbles in a foaming bath, through a repeating social pattern as people have learned from one another.[11]

Twitter has grown precisely because the founders did not try to control it. They encouraged the creation more than 70,000 add–on applications such as Tweetdeck and Twitpic, to make the basic service more useful, allowing people to organise their tweets into columns, to search and to send pictures and videos along with text. These applications turned Twitter from a product into a system. Twitter had encouraged the growth of this vast cloud of supporting applications by making its application programming interface available to outside programmers. That in turn has attracted a host of developers who have worked out how to adapt Twitter to a wide range of devices, such as mobile phones and cameras, and social media and web services, such as Facebook and LinkedIn.

Twitter is an example of a system that almost assembles itself. Another example is Ushahidi which allows many disparate users to share information in real time, especially in the midst of crisis. A group of activists developed the original Ushahidi website in the aftermath of Kenya's disputed 2007 election.[12] Across the country witnesses to violence and civic action submitted information, via the web and mobile phones, to build up a map of where there were violent clashes and where there was peace. Ushahidi grew quickly to have 45,000 users in Kenya. From there is spread to the Congo and South Africa and thence to Asia and South America where activists used it to monitor elections in Mexico and India. Ushahidi is a platform for creating a system on the fly. These fleeting, lightweight systems are quite different from their industrial and Victorian forebears.

Modern schools still bear traces of their Victorian roots. Containers were perfectly designed for the explosion of global trade in the 20th century. Social media platforms have brought to life the Internet's dull infrastructure of cables and routers.

Yet despite their differences, systems like these have common ingredients. Systems create experiences that are repeatable, reliable and often standardised, like the 140 character tweet. A system should work the same way wherever it operates: an ATM machine has the same interface wherever you go; boarding an airplane is pretty much the same whichever airport you use. Containers, schools and Twitter look the same the world over. Systems are codified, explicit and measureable.[13] It is precisely this blindness to the context they operate in and the different people they serve that makes systems so powerful. Simplification, standardisation and impersonality are the price we pay for scale, reach and reliability. Yet this also allows systems to be put to a startling proliferation of uses. The modern secondary school now teaches many more different courses than its counterpart 100 years ago. Container ships carry the material answer to virtually every human. Twitter can accommodate almost any message so long as it is condensed to 140 characters.

Despite their differences, systems innovation involves some common challenges and ingredients.

4 INFRASTRUCTURES, ALLIANCES AND MOVEMENTS

Infrastructure

The most obvious manifestation of a system is the infrastructure needed to support it: schools and playgrounds, ports and cranes, computers and cables, electricity pylons and power stations. Systems need an infrastructure to support their distribution to a large market. The more expensive the infrastructure the most significant the role of finance in bringing the system to life. Heavy–duty industrial systems, such as containerisation, require heavy investment. In contrast, the development of the fleeting systems of the Internet age, created almost on the fly out of decentralised resources, require relatively modest up–front investment. Instead they require lots of partners, developers and consumers to make lots of smaller investments that all come together.

The classic example of a system that was heavily dependent on infrastructure and investment is the way electrification spread at the end of the 19th century.

In 1880 electricity generation and transmission in the US and Europe was a piecemeal business, confined to pockets of urban centres. By 1930 electricity systems were national with many millions of consumers connected to them. Thomas Hughes's magisterial account of electrification, *Networks of Power: Electrification in Western Society 1880 – 1930* argues that system developed in phases. The first phase was lead by entrepreneur–inventors, like Thomas Edison, who turned an idea intro a usable product. In the second phase, the basic technology was picked up by an eclectic, disorganised group of borrowers – inventors, entrepreneurs, financiers, engineers – and opportunistically taken to different places, each with different challenges. In the third phase, the system ran into what Hughes calls 'reverse salients': bottlenecks that held back its development. These critical problems became the focus of a new round of problem–solving innovation. The first electricity systems were quite localised and used direct current. However, once the systems were stretched over longer distances the DC system became uneconomic. The solution was the Alternating Current which was better suited to transmission over larger distances. Once these problems were ironed out, the system was robust enough to acquire momentum – velocity, mass and clear direction. Financiers and utilities played a critical role in this phase, funding the roll out of the infrastructure to create the system.

Systems that are infrastructure–heavy will require more up–front capital investment from either the financiers or government. The development of the school system was less capital–intensive than electrification but even so, the vast resources needed to build national systems meant the state was the player most capable of this task. Twitter and Ushahidi, by contrast, largely piggyback on an infrastructure that already exists. They are beneficiaries of the falling costs of computing which have lowered the direct capital costs involved in setting up a communications business. Cloud computing takes this a step further allowing businesses to rent infrastructure – computing resources – as they need to.

Systems need infrastructure and infrastructures need investment. The more that investment has to be up–front, the bigger the risk and the more significant the role of finance in shaping systems. The less important infrastructure is the more opportunity for new entrants with few resources to create new systems. But those that succeed have to be good at other things: they need to excel a building alliances around their products and persuade consumers to change behaviour en mass.

Alliances

All these examples of systems innovation involve the creation of new products and services, often incorporating new tools and technologies: lessons in classrooms with blackboards; containers to carry goods; a simple tool to communicate online. Each of these systems, however, also depends on other services that wrap around the basic product. Containers need trucking and railway companies to change how they operate. Twitter has grown because of all the services that can be added onto it. The basic products on their own are not enough to generate real momentum: they require complementary services and software to realise their full potential.

Systems bring together different elements to achieve a common purpose. A single company almost never has all the skills and assets to provide the full range of these complementary services. As a result, systems innovation always involves alliances of partners, suppliers, distributors and developers. A lead innovator has to bring others in around its product. Systems innovators do not have to be the best product innovators but they do have to excel at alliance building.

Building these alliances usually involves three ingredients: economics; governance and design.

Alliances: The law of shared value

At the turn of the century Hollywood studios were keen to start using digital effects in films, including 3D. Films with digital effects would have to be seen in digital cinemas, rather than on grainy DVDs bought from bootleggers. Digital cinema promised to make the entire film and cinema system stronger. Yet there was a seemingly insuperable problem and it did not lie in the technology nor in the product. Cinema owners could not see the value in shifting from analogue to digital projection. The digital kit would cost $70,000 – $90,000 per screen and projectors only had a life of ten years. There were few films that would benefit from digital projection. For all its promise digital cinema and so digital film made little progress.[14]

The deadlock was broken by an economic innovation. The studios set up a shared financing scheme, the Virtual Print Fee, which gave movie theatres a subsidy of up to 80 per cent of the costs of shifting to digital projection. In 2009, James Cameron's film *Avatar* announced the potential of digital, 3D filmmaking. By the end of the following year, largely thanks to the VPF, almost 40 per cent of US cinema screens had digital projection and 25 per cent worldwide. The key to the spread of the innovation lay in the combination of the products (digital projectors, computer generated effects) with financial innovation (to subsidise the take–up of the new technology.) In order to create a new system the studios had to break cinemas' allegiance to old technologies. To lead them into a new alliance they had to share, up–front, some of the value the new system would create.

In alliances that support new systems, value cannot be created unless it is shared amongst the alliance. If value is not shared fairly among the alliance, the innovation will fail to take off, even though the product at the heart of it works perfectly.[15]

The governance of alliances

Systems innovation is a highly–collaborative endeavour. It involves bringing together many actors to make complementary investments. Orchestrating this is necessarily a highly–political process to determine how revenues and risks are shared between different players in the system, how standards are established and who controls knowledge and intellectual property. Containerisation and digital cinema both spread only once competitors had agreed on common standards. Intel developed its standards for the USB port by orchestrating an alliance of independent software developers around its approach.[16] Sony's VHS standard beat out Matsushita's technically superior Betamax standard because Sony got more film studios to back its approach and so it was able to offer more content. Systems innovation depends on alliances, and alliances need to be governed, explicitly or implicitly. That takes political innovation as well as financial and technical innovation.

The power of large companies to dominate the alliances and the terms on which partners take part, is now one of the most contentious issues in business. Being part of Apple's ecosystem means playing by Apple's rules. Google's system depends on the availability of large quantities of free information: it does not pay for content, which is why publishers are so wary of its influence. Facebook can be a platform for building a business but that comes with rules and restrictions imposed by the landlord. The political character of the alliances behind systems can range from an open, chaotic bazaar – Twitter – to something more like landlord and tenant – Facebook.

The design of alliances

Alliances only create systems when all the components from different players fit together, creating a seamless experience for the customer. To achieve this most systems adopt a degree of modularity. Tweets are modules of communication. Containers are modules for cargo. Lessons are like modules that fit together to create a timetable. The degree to which systems are tightly integrated or open and modular, shapes their character. Take computer systems as an example.

Modularity has been a feature of computer system development since at least the 1960s, when IBM was developing its System 360 computer. The S360 was a tightly–coupled system: a change in one component could have an impact on many others. Fred Brooks, who was responsible for the project, wanted everyone involved to be kept abreast of what everyone else was doing. Daily notes of changes to the programme were shared with everyone. Soon people were starting work each day by sifting through a two–inch wad of notes on design changes. Adding people to the project meant more work got done, but more misunderstandings were created and with them came more bugs. When the daily wad of design changes was several feet thick Brooks decided the only way to make the project manageable was to break the S360 into discrete modules that could be worked on separately. A core team set the design rules which specified what modules were needed and how they work together, almost like Lego bricks. That allowed module makers to concentrate on their module while the core team looked after the system as a whole. More effective modules could be fitted into the system without having to redesign it from scratch, so long as they respected their interface with other modules. This shift to modular design partly spurred the vast growth in the computer industry as swarms of companies set up to make modules for specific tasks. In 1940 there were just three computer projects in the world: all of them were densely integrated, tightly–coupled systems. By the late 1970s there were hundreds of thousands of computer companies, most of them making modules for other systems. Brooks was a classic system innovator: a change in the division of labour and knowledge allowed for an explosion of diverse and decentralised creativity that was still brought together into a coherent single system.[17]

A good example of how all three of these aspects of alliance and system building came together was the building of Terminal 5 at London's Heathrow airport.

When BAA set out to build Terminal 5 it studied 12 of the largest airport building programmes in the world and concluded that unless it took a different approach Terminal

5 would be delivered a year late, about $2 billion over budget and lead to the deaths of at least two construction workers. BAA was determined to avoid that. Terminal 5 opened in March 2008, on time and within a budget set in 2003. Terminal 5 was built as a 'system of interconnecting systems': two large terminal buildings, an air traffic control tower, road and rail transport links, a hotel, a 4,000 space multi–storey car park, 13 kilometers of tunnels and an infrastructure of gates and other equipment on the airfield.[18] The supply chain to deliver the project was even more complex: 80 first–tier, 500 second–tier, 2,000 third–tier, 5,000 fourth–tier and 15,000 fifth–tier suppliers. The project was sub–divided into 16 major projects, with 147 sub–projects (like modules), with the smallest valued at $2 million and the largest $600 million.

BAA managed to deliver this system–of–systems by creating an alliance among its partners and contractors. BAA used its economic leverage to create a different approach to governance: it gave suppliers incentives to collaborate in solving problems. To bring people together, BAA created a 'single model environment' that all 80 first–tier suppliers worked from. This shared model was a political innovation as well as a technological step forward and a new design tool: it became a collaborative space for joint problem solving. Suppliers were enrolled in a training programme designed to foster collaborative problem solving. Adapting techniques from offshore oil and gas supply industry, many of the components were made offsite as modules, which could be tested before they got to the site, where they were assembled. To orchestrate the timely delivery of all these components teams used just–in–time techniques from the car industry. At its peak the project had to cope with transporting 8,000 workers a day and handle more than 250 deliveries an hour.

Yet despite this success in building Terminal 5 on time and in budget, the place was a chaotic mess when it opened. That was largely because the operator – British Airways – had completely underestimated a further challenge involved in making a new system work: consumer behaviour.

Movements and behaviour change

System innovation fails unless it also brings about widespread changes to behaviour. A new system only comes to life when consumers start to use it en mass, changing their behaviour as they do so. This is not a new phenomenon. A prime example is the development of the postal system in 19th century America.

In 1820 most Americans did not engage in any form of long–distance communication. By 1870 most people did. This fundamental change in the culture of communication came about through the postal system, which meant that for a small fee people could connect to a national network of mass, participatory communication free from state censorship. The crux of that change was postal legislation between 1845 and 1851, heavily influenced by Rowland Hill's reforms in the UK, which dramatically lowered the price of sending a letter and so brought the postal system in reach of the masses. Between 1840 and 1860 the number of letters carried by the US postal service rose from 27 million to 160 million.[19]

The postal system needed an infrastructure to create a national network. By 1850 there were 22,000 post offices where mail got taken in, sorted, held, and distributed. People could access this infrastructure with a simple, easy to use tool in the form of the cheap stamp.

What brought the postal system to life, however, was the mass, everyday culture of letter writing. That required new norms, behaviour, habits and expectations. Letter writing became a widely–spread capability, which people largely picked up from one another, peer–to–peer, through emulation and copying. During the middle decades of the 19th century, Americans in their millions taught one another through their exchange how to compose letters and how to read them as gestures of self–expression. As David M Henkin puts it in his history *The Postal Age*: *"Americans began producing and circulating in massive numbers something that had never before been an instrument of everyday sociability among ordinary people: the personal letter."* This went hand in hand with other social changes. The post provided a culture of national connectedness in an era of increased mobility. It allowed women far greater scope for communication, allowing a flowering of intimate self–expression through letters, which in turn provoked moral panic in Congress. In 1820 only an elite of Americans wrote letters; in 1870 most people did. The postal system enabled that change but was also brought to life by it.

All true systemic innovation involves behaviour change. Electrification involved people using light, heat and power differently. Dockers, shippers and manufacturers had to change how they worked to make the most of containerisation. Schooling has involved far–reaching changes to the nature of childhood and family life. Social media has spread through emulation and imitation.[20]

System innovation involves a powerful combination of new:

- Products, services and technologies (tablet computers, containers, stamps, digital projectors);
- Infrastructures that make these innovations widely available;
- Alliances of partners who provide complementary services, software and assets;
- Consumer norms and behaviour, which often emerge peer–to–peer, through a process of social learning, copying and emulation.

These basic common ingredients of systems innovation, however, can be combined in many different ways.

5 THE VARIETY OF SYSTEMS

Systems can be ranked along several dimensions, which together shape how they work and who has the power to change them. Often systems rely on a combination of these ingredients. This explains why systems which share some basic features can nevertheless work in very different ways. As a result, the strategies available to people trying to change them are also very different.

Heavy/light

All systems need infrastructure but some rely on heavy capital investment – containerisation – while others reconfigure and repurpose an existing infrastructure – social media's use of the communications infrastructure. Heavy systems often require capital investment which means those with access to finance have a larger say over how the system develops and new entry is limited by high capital costs. However, a huge opportunity for disruptive system change comes about when old and heavy systems are suddenly confronted by new alternatives that are lighter and cheaper. This is what is happening to many media industries such as newspapers, which until very recently could deter new entry in part because of the high costs of setting up print plants and distribution systems. Newspapers were a heavy system. The web has dramatically lowered the costs of creating and distributing content. Mobile phone–based banking systems could provide a similar threat to traditional banks.

Adapting/creating

Electrification created an entirely new system from scratch. System building on a blank sheet is a highly risky business, in which new technologies have to be tested, refined and proven; investment secured; infrastructure built; consumers persuaded; profitable businesses launched. When Malcolm McLean started work on his containers he wanted to replace an existing, inefficient system for shipping freight. Building the containerisation system involved breaking and then displacing an existing system of docks, cranes, ships and warehouses and the dockers who worked in them. Challenging and replacing an existing system, is not just risky: it often involves costly conflict.

In the fast growing, emerging economies of the developing world there is a huge need to create new systems, in almost every sphere of life, especially to cope with rapid urbanisation. In the developed world, where systems are more ingrained the challenge is to adapt old systems – for example to switch to different kinds of energy systems – or to change existing systems from within. Adapting and reforming existing systems is difficult for all sorts of reasons, but one of the most important is that it usually involves conflict.

Dominated/negotiated

Some systems are dominated by a few players: electricity generation and distribution. Some are dominated by a single player: BAA as the client at Terminal 5; Apple the landlord overseeing its ecosystem to toiling appserfs. Others are more open, there are many more players and no one player dominates: power is negotiated and shared. This is truer of some more open source systems – like Linux, Wikipedia and Ushahidi – although even these communities are often more structured than they might first appear. If a small group of players dominate a system then they can drive change, for example in standards and new technologies. But they can also create blockages to change that are difficult to budge. Systems that are open to many players can be more fluid and inventive but bringing together many different players to agree a common approach is often time consuming. The spread of digital cinema is an example of how an industry dominated by a few players – the studios – nevertheless had to negotiate with hundreds of distributors – the cinemas – to persuade them to adopt new technologies.

These three most basic dimensions of systems **heavy/light, adapted/created** and **dominated/negotiated** then have a bearing on other features.

Stable/fluid

If the knowledge base for an industry is relatively stable and there is little scope for fundamental innovation, then the industry tends towards consolidation around a set of common standards and few dominant players: electricification and VHS are good examples. There is little room for new entrants to come in with novel approaches.

If the underlying knowledge base is more fluid and open, then the opportunities to create new models are much greater. Walter Powell's extensive studies of innovation in biotechnology show that in an industry where the knowledge base is both complex and expanding, the locus of innovation will be in networks of learning, rather than an individual institution. Innovation in these settings is as much as product of the 'field' as it is of the particular 'particles' the companies, that make it up.[21]

One of the prime sources of the power to dominate a system is control over knowledge: the medical profession's dominance over the health system, in part reflects the dominance of the medical view of health and the priority it gives to medical as opposed to social and public health. Dominant players will always have a strong incentive to limit and control potentially disruptive new knowledge creation to secure their position. It also follows that one of the main strategies for system reformers and innovators is to force open closed systems to new ideas: one example in education is the way digital technologies are being used to challenge ingrained approaches to teaching.

Tight/loose

Twenty cars moving at high speed, nose to tail, in the outside lane of a motorway are a tightly coupled system. There is very little margin for error. If one car slows down suddenly the entire cavalcade will crash. Tightly coupled systems can be highly productive and yet they are also prone to catastrophic failure. The financial system in 2008 was like a cohort of speeding cars in dense fog: by that stage it was just a question of when and how it was going to crash.

As societies modernise and become richer, their networks – of finance, trade, governance, communications – tend to become more complex, interconnected and faster: they add more nodes, increase the links between the nodes and they increase the speed at which stuff moves from node to node. Greater connectivity within systems makes societies richer and more productive by allowing them to operate with greater scale and reach; larger networks can also be more diverse and open to learning; greater connectivity can make systems more resilient if they can draw on a wider range of skills and resources to cope with shocks.[22]

However, tight coupling comes with downsides. Our interconnected air transport systems mean viruses can spread quickly from remote villages to urban centres. Tightly-coupled systems find it hard to innovate, especially if change in one component has knock-on effects on other components.

Getting the most out of the connectivity that systems allow while limiting the downsides is one of the chief challenges facing systems innovators. They have adopted three linked strategies to cope. The first is the approach Fred Brooks took with the S380 computer: breaking down a system into modules makes it more manageable. A second, cruder, approach is to introduce buffers and barriers into systems to prevent risks spreading. A firebreak is a buffer. So is the separation of high street banks from higher-risk investment banks. To retain their stability, systems need buffers that can be used to slow down change when it gets out of hand. Learning when to install or retain buffers is a part of systems innovation. The third approach is to create enough spare capacity in a system so it can quickly route its way around a problem, thus preventing the entire system from becoming snarled up. The Internet was designed from the outset as a decentralised system, with no command centre, that could reconfigure itself even if a part of it was disabled by a nuclear attack.

Public/private

Although the technology of the electricity system was standardised at the turn of the 20th century, electrification spread in different ways in London and New York. In the UK local politics played a much more important role in shaping the market which meant there was greater attention to providing services for consumers who could no pay. In the US electrification was regarded as a profit making business: services went first to where businesses and consumers could afford to pay. Having access to systems for energy, water, transport, communications, education, health is vital to modern life. The terms on which systems operate is bound to be a political not just a commercial issue. There are very few entirely private systems, in which the government plays absolutely no role in shaping, even if that role is limited to standard setting, regulation and access. As systems innovation becomes more important, so government's role in innovation will expand. Governments may have little expertise in 'picking winners' among consumer products. But they do have a role in shaping systems which affect the lives of citizens, even if those systems are mainly made up of private companies and especially if powerful companies come to dominate systems which provide important public goods such as health, water, transport and education.

Complicated/complex

A fleet of military ships is a system. At Trafalgar Nelson defeated the vastly superior French and Spanish fleet by leapfrogging the conventional system for organising a battle.[23] The established system for naval battles in the early 19th century was for two parallel lines of vessels to trade broadsides at very close quarters. Having ships in a line kept discipline even when the commander at the head of the fleet could not communicate down the line. Nelson knew this approach would reward the larger French and Spanish boats which had greater firepower. So working intensively with his captains, Nelson devised a different system. To make the most of the speed and manoeuvrability the British ships would attack perpendicular to the French and Spanish lines, cutting into them. This would leave the British bows vulnerable to broadsides but Nelson's gamble was his attack would break up the enemy lines and turn the engagement into a collection of small battles in which the ability to move and work together would be decisive. Once they were in the battle, the British ships had to self-synchronise to collaborate in attacking larger enemy ships. Although Nelson lost his life, not a single British vessel was lost. The French and Spanish fleet lost 20 ships, with many more badly damaged. Nelson was the archetype of the modern leader of a complex system which is impossible to control: he ensured his captains had a shared sense of purpose, knew what they were doing, would help one another out and share information. The more open, fluid, complex systems are, the more they need this kind of leadership.

A watch is a complicated system. There are many moving parts but a skilled watchmaker should be able to repair a broken watch by finding a definitive solution. Stacking containers on a ship is a complicated problem. A cloud is a complex system. Like a watch, there are many moving parts, water droplets, but they can take a bewildering variety of forms. There is no single, definitive solution. Clouds rarely retain their shape for more than a few minutes and often migrate from one form to another in the course of a day.[24]

The behaviour of complex systems like clouds is difficult to predict because small and unforeseen change can have a big impact. That makes it very difficult to plan in detail how they should be managed. As Robert Axelrod and Michael Cohen put it in *Harnessing Complexity*: *"The complex systems world is a world of avalanches, of 'founder effects' (where small variations in an initial population can make large differences in later outcomes), of self-restoring patterns (in which there can be large disturbances that do not ultimately matter), of apparently stable regimes that suddenly collapse. It is a world of punctuated equilibria (where periods of sudden rapid change can alternate with long periods of stasis) and butterfly effects (where a small change in one place can cause large effects in a distant place)."* Yet these are not complete disorderly systems that are so turbulent that useful lessons can never be learned. Complex systems have structure. They can be designed to promote beneficial adaptation and self-organisation. They require a different kind of leadership from that Nelson deployed at Trafalgar.

Most modern systems are both hideously complicated and bewilderingly complex. That means systems leaders need to deploy a mix of skills. Such systems, complicated and complex, are a hallmark of our age as the factory was in previous decades. A good example are the home delivery systems run by online retailers.

Zappos, the US online shoe retailer, for example promises overnight delivery of any of four million items it stocks in a high-tech warehouse in Louiseveille, Kentucky. The Zappos' system, which allows for a seemingly infinite selection of consumer goods to be delivered to you overnight (and then allows you to return the things you do not want), is a sign where modern systems are headed.[25]

Human pickers, guided by computer generated lists, wander around collecting very low-volume items. The higher-volume sellers are organised on carousels, which spiral round, to present a human picker with just the item they need. All over the warehouse floor small orange cubes – robots – scurry around, picking other items that are easier to find. Nothing is static because the racks themselves move, gliding backward and forward, to make it easier for the robots to find what they are looking for. There are barcode scanners everywhere to log where things are in the system, but there is no Dewey library filing system, with trainers over here and walking boots over there. Instead the storage system is modelled on a computer hard drive, which stores information randomly wherever there happens to be free space and retrieves it when necessary. Arriving inventory is logged by barcode, given a location and then just finds the next available space in an ever changing mosaic. The entire system is managed by an omnipotent inventory system called Genghis. It takes just 12 minutes for a robot to find, pick, pack and prepare an item ready for delivery through the UPS hub, just 15 minutes down the road. The system reduces to just a few hours the time lag between the formation of a desire and its fulfilment.

The Zappos warehouse is a reflection of the society we are becoming, just as Henry Ford's factory system was in its day. Our lives depend on systems that are both highly automated, standardised and complicated, yet complex, intelligent and evolving. Seen from above, the warehouse looks more like a badly organised barn dance rather than a regimented production line.

These ingredients can be combined in many different ways but it is not hard to see that systems that are heavy, closed, complicated and tightly coupled work very differently from systems that are light, open, complex and loose. The industrial systems we have inherited are heavy and complicated, the systems we are creating are more likely to be complex and light.

What lessons can we draw about the skills needed for leadership of systems innovation?

6 LEADING SYSTEMS CHANGE

Until the year 2000 the several thousand inhabitants of Samso, a small Danish island in the Baltic, heated their homes with oil and imported electricity. The people of Samso were not radical environmentalists. Yet they realised that their dependence on imported energy threatened their security and the environment. After winning a government–sponsored competition to become an 'eco island', Samso embarked on its own effort to innovate an alternative energy system for the island. To achieve that, Samso needed a new heavy–duty infrastructure. The wind turbines, which cost a million dollars each, were purchased collectively. But behaviour had to change as well. People recognised they needed to both generate and use electricity differently. The systems innovator at the heart of the creation of the island's new energy system, Soren Hermansen, a lifelong Samso resident, sold the project relentlessly in local meetings and seminars till he got a committed group of local leaders around him. This core alliance then persuaded others to follow their lead. Soon Samso residents were learning from one another, not just from Hermansen, about how to use energy differently. New norms became established alongside the infrastructure. By 2005 the island was generating more energy from wind power than it was using. Fossil fuel usage had been cut in half. Samso's shift to a low–cost, low–carbon energy system contains all the ingredients of system innovation: a new an alliance of innovators, creating a wider movement of change, enabled by an underlying new infrastructure and new technologies. We will need more systems innovators like Hermansen.[26]

They will pursue a mix of four strategies. They will drive, repurpose, reconfigure and leapfrog systems.

Drive

The most common approach is relentless, incremental innovation to drive a system to higher levels of performance. Ben Levin, is a prime example of this kind of systems innovator.

When Levin became the top government official in the education system of the state of Ontario in Canada he became responsible for a system with 5,000 schools serving two million children. Levin wanted to improve performance across the board, for all children, in all schools. His fascinating account, *How to Change 5,000 Schools*, tells the story of a relentless effort to raise standards, by improving teaching and strengthening school leadership to focus on a few stretching targets: improving literacy and numeracy across 4,000 elementary schools and graduation rates from 800 high schools. Levin's strategy succeeded: literacy scores rose from 54 per cent to 64 per cent and graduation rates by 7 per cent to 75 per cent. Change at this scale needs a concerted strategy; it cannot be left to chance.

Many of these strategies for system–wide change trace their roots to the ideas of Michael Fullan, professor emeritus at the Ontario Institute for Studies in Education at the University of Toronto, who worked with Sir Michael Barber, the architect of the British government's literacy and numeracy strategy in the late 1990s. Barber and Fullan recommend focussing relentlessly on how to improve teaching to hit a small number of measurable targets.[27] Both stress the importance of building the collective capacity, motivation and will of teachers to change. However, in practice the people on the receiving end can experience these strategies as centralised, mechanistic, and narrowly focused. They leave little room for local initiative and reward compliance with formats handing down from on high.

These strategies rely mainly on lower–level levers in Meadows's toolkit: improved information, better infrastructure and new standards. Driving systems to improve assumes that the goals of the system do not need changing. These strategies focus on how to achieve higher performance and they favour easily measurable inputs and outputs.

Repurpose

Driving a system to do more will not be enough if something different is needed. When the goals and ends of the system are in question then systems innovation has to focus not merely on new means but on a new purpose. Repurposing a system requires opening it up.

The system most evidently in need of repurposing is the financial system. The high–speed pile–up which caused the 2008 financial crash and subsequent recession is leading to changes in bank regulation, strategy and behaviour. Banks have been required to hold more capital and to become more cautious. More effective buffers are being erected to separate high street banking from higher–risk investment banking. Yet it is less clear that banks are being made to see their purpose differently. Banks recognise the need to behave more conservatively but they are keen for the frameworks in which they operate, their goals and incentives, to remain largely untouched. Against that there is a clear popular demand for a different kind of financial system, one which is less unstable, risky and unreliable and more focussed on the basics of lending, borrowing and saving. The political debate over the social responsibilities of the banking system has a long way to run.

A growing band of critics argue that education systems also need a new purpose to encourage young people to develop the skills needed in a modern, innovative economy. Schools that shepherd children through tests will not impart the social and entrepreneurial skills they will need to prosper at work. Even when schools are hitting the target, with highly methodical teaching strategies to transmit knowledge, they can still miss the point.

"Education can no longer be productively focussed primarily on the transmission of pieces of information that, once memorised, comprise a stable storehouse of knowledge," according to Linda Darling–Hammond, professor of education at Stanford University. *"Instead, schools must teach disciplinary knowledge in ways that focus on central concepts and help students learn how to think critically and learn for themselves, so that they can use knowledge in new situations and manage the demands of changing information, technologies, jobs and social conditions."*[28] Tony Wagner, Professor of Education at Harvard University argues that modern learning should be organised around interesting questions children should explore, rather than the answers they should memorise to get top marks in exams.[29]

According to Darling–Hammond and Wagner the new mission of schools should be to prepare children to work in jobs that do not exist, to solve problems that are not yet apparent, using technologies that are still to be invented. That means equipping them with the ability to apply and reapply knowledge in inventive ways. Collaborative creativity should be at the heart of modern education rather than the culture of compliance of schools in the industrial era.

Reconfigure

A third strategy is to reconfigure established systems, by overlaying them with a new system – primarily an information system – that will allow the physical resources to be used in different ways. The most widely touted example is the 'energy Internet' which many predict will reconfigure the traditional electricity grid that Thomas Edison created.

The smart grid will change how and where information flows within the energy system to allow supply and demand, wastage and loss, to be managed much more effectively. It will turn the electricity network into an intelligent system able to reconfigure and synchronise itself. Appliances that use energy will be able to communicate their status to the grid. Consumers will able to opt to have aspects of their energy usage managed remotely by the grid, for example to turn off items that are on standby. A smarter grid should be able to reduce wastage and loss in transmission by finding more effective routes from the generator to the user. Smaller, decentralised suppliers will be able to join the grid, becoming producers of energy as well as consumers. This should create an incentive for buildings to be retrofitted and designed to generate energy, through solar and wind, as well as using it. The smart grid is still in its infancy. But it offers the possibility that a classic industrial system – the electricity grid – could be combined with sophisticated information system to create a new hybrid, both complicated and complex, with a new purpose to minimise carbon emissions.[30]

These intelligent systems will spread when almost all objects come with a digital marker attached that will allow them to be identified and tracked. That data will be sifted and mined by intelligent machines, looking for patterns and connections, clues to what we have and what we might need, what we have bought and what we might be persuaded to buy. Many of the basic transactions of the economy will be conducted seamlessly by machines talking to one another, sorting things out without our realising it. The economist Brian Arthur calls this the second, shadow economy:

"It is vast, silent, connected, unseen and autonomous (meaning that human beings may design it but are not directly involved in running it). It is remotely executing and global, always on and endlessly configurable. It is concurrent which means that everything happens in parallel. It is self–configuring, meaning it constantly reconfigures itself on the fly and increasingly it is also self–organising, self–architecting and self–healing."[31]

A second skin of information and software, is growing over the physical economy of goods and services, tracking inventory, analysing spending patterns, shifting money around, adjusting prices to make the most of demand.

Leapfrog

Huge new opportunities are opening up for innovators to leapfrog old systems using new technologies. An early example is the spread of mobile banking systems in the developing world. The most famous example is M–Pesa, the Kenyan mobile banking system, which has 17 million registered users and allows participants to transfer money without going through a bank, using text messages. The money can be collected from local retailers who act as M–Pesa's physical distribution network. M–Pesa has created a banking system without needing either ATM machines or a large dedicated branch network. Pakistan has become one of the most innovative places in the world for mobile banking through services such as Tameer Bank's Easypaisa, partly thanks to the State Bank of Pakistan's far–sighted moves to encourage the market. About 1.5 million customers are making about 30 million transactions a quarter through their mobiles, using a network of 20,000 agents, mainly local shops, to collect their cash. Only 25 million Pakistanis have bank accounts but 120 million have mobile phones. The potential for the entire banking and payments system to move onto a mobile platform is huge.

In health, too, many innovators have high hopes that mobile devices and networks will allow the creation of low–cost, community–based healthcare systems in societies where there are few doctors and hospitals. Already mobile networks are being used to: deliver advice and information to patients; collect and record information; diagnose and test for conditions, such as diabetes; manage the work of nurses and doctors in remote areas; galvanise peer support for patients; make payments for services.

Medical technology is beginning to migrate out of large organisations – hospitals and universities – into households, communities, small businesses and the hands of care workers, mentors and consumers. Diagnostics for All has developed a diagnostic test for anaemia and blood pressure that can be used at home at a cost of $0.10 per test.[32] The tests just require a drop of blood or urine and can be printed off a standard printer. Imaging the World has a low–cost ultrasound that can be used in homes and which sends images over the mobile phone network for trained staff in a clinic to interpret.[33] The Hemoglobe, developed by Jhpiego, a partnership based at John Hopkins, transforms a rural health worker's cell phone into a non–invasive, prick–free, hemoglobinometer, which delivers not only a read out on screen to the health worker but also automatically transmits data back to a central database.[34]

If these low–cost devices – and their providers – can be brought together in an alliance, then they could create a new system for providing people with healthcare support, without needing an extensive heavy–duty infrastructure of hospital.

This is no more than a glimpse of where we might be headed as pervasive, mobile information networks converge with new medical and genetic technologies. Then, as some futurists predict, we might get entirely new kinds of systems which blend the technological, the social and the human in entirely new ways. In the next decade these new hybrid systems will move from theoretical possibilities to experiments and prototypes.

Conclusion

Systems make modern society possible. Yet they also make life hard when they are unyielding, clumsy and self–interested. Systems make us more efficient when they support our lives seamlessly and yet we feel trapped by systems when they seem to work against us. That friction emerges from the growing mismatch between the systems we have, largely inherited from the industrial era, and those that we need. That mismatch creates the space and the demand for systems innovation. It is dangerous to generalise about the features these new kinds of systems might have but it is a fair bet that they will be both complex and complicated; make far more effective use of resources, particularly energy, for both economic and environmental reasons; operate largely unseen in the background to our lives; adopt far more human, emotionally appealing, interfaces when we come across them; work far more intelligently and deploy themselves more adroitly as situations demand, reconfiguring themselves as they need to; operate at a far greater scale even than the systems we have, reaching across the world but also down into the minutiae of our daily lives.

Creating systems of this kind is the real challenge of innovation, not just to drive the systems we have to higher levels of performance but to open them up to new ways of working, give them a purpose fit for the times, reconfigure how they work and to leapfrog to new kinds of systems, which will support us to live more successful lives.

7 THE NEW RULES OF INNOVATION

These are ten tips to follow to become an effective systems innovator.

1. Even a great product is no guarantee of success

Superstar designers might garner the acclaim for iconic products, but much of the value they create lies in the systems that support and enable them. Products are often just the front door to these systems. New systems – from electricity to the Internet – create platforms that make us all more efficient and productive. Having a great product is no guarantee of success, unless you can assemble around it the complementary services, software, support, infrastructure and channels that allow consumers to use it easily and effectively.

Electric vehicles will be an important test case. Electric vehicles are cheaper to run than traditional cars and better for the environment. However, they also cost more to buy and to maintain. The main problem is the battery that powers the vehicle, which needs recharging every 200 miles or so. The problem is not solved by installing a mass of recharging points because it still takes a long time to recharge a battery, especially compared to filling up a car with petrol. The electric vehicle is a classic example of a promising product that will only become a success when it is seen as a system, which will involve not just a new infrastructure of charging points but also new financial models for purchasing batteries. One of the most promising solutions is being developing by an Israeli company Better Place, which is proposing to create battery recharging stations where a car can swap its old battery for a new one. The change should take the same time as filling a tank with petrol. However, to make the system work, Better Place, has to own all the batteries, which it recharges and rents to the car owner.[35]

2. Different systems need different approaches

A tightly–coupled, complicated system that requires heavy investment requires a different approach from one that is loosely structured, complex and light on infrastructure. Sometimes the best approach is to outmanoeuvre a heavy system with a more agile, collaborative networked system: witness the rise of mobile banking systems in places such as Kenya and Pakistan where traditional banking infrastructures reach a minority of the population.

Systems dominated by a few players, cannot change unless these dominant players are prepared to budge or can be levered out of the way. Their position is likely to rest on their economic power – they control how money flows through the system and knowledge, which determines what standards are accepted. More distributed, emergent and unscripted systems need leading as if they were a community.

3. Systems innovation turns on alliances

Your capacity to innovate will depend on who is part of your alliance. Creating new products relies on creative teams. Changing entire systems, however, requires alliances of partners who will be co–innovators working alongside you and distributors who will take the product to market. Successful systems innovators create constellations of other actors aligned around them.

4. No value will be created unless it is shared

Alliances only create value if they share it. Value will not grow if it is all captured by just one partner. It has to circulate. That requires a social contract to determine how value should be shared out among the alliance members. These social contracts for innovation require economic agreements – who gets what share of the revenue – but also technical standards and design rules to enable the different partners' contributions to be brought together. Some alliances depend on explicit and open collaborative governance. There are already many different versions of these social contracts for innovation, from open source and Wikipedia, which is like a digital commons, to Apple's approach to its app developers which is much more like a landlord with tenants. Orchestrating these social contracts – what Finnish innovation strategist Ilka Tuomi calls the *"politics of innovative ecologies"* – is the critical role of systems innovators.[36]

5. System innovation needs behaviour change

Leading mass behaviour change is like creating a social movement, in which people learn from and lead one another. The most powerful brands – like Apple – create a gravitational pull, drawing partners and consumers into their orbit. Innovation and economic strength is a function of the total capability of the movement, not just the team that creates the main product. Some of the most interesting new spaces for innovation – organic food, alternative energy – are being opened up by social movements. New kinds of consumer behaviour can be the starting point for systemic innovation.

6. Systems innovation requires a mix of leadership styles

As system innovation involves so many components, it also requires many different leadership styles. Creative teams – like film crews – need producers and directors to bring them together in an intensively collaborative activity. Acting as a disruptive entrepreneur requires a leader who can be more like a pirate leading a crew, launching raiding parties on the status quo from the margins. Building alliances and movements, however, requires a leader who is more like a community organiser or the political leader of a coalition.[37]

In relatively closed, stable systems, in which tasks are repetitive and there are a few dominant players, leadership might be exercised through hierarchy, rules and contracts: relatively hard and fixed forms of power. In more open, emergent systems, with many players operating in more fluid environments, and where the task is to create solutions rather than repeat tasks, then successful leadership will be more like leading a community of volunteers, who cannot be instructed. Leadership is likely to be far more interactive and distributed rather than concentrated and instructional.

7. Move at the right time

Steve Jobs was not the only system innovator who excelled at timing his run. Take e–book readers as an example. Sony, the Japanese consumer electronics company, was the market leader from the introduction of the first digital e–book reader in 1990. Sixteen years later it was still in the lead, with the launch of the PRS–500 which was slim, elegant, had a long battery life and a back–lit screen that was easy on the eyes. The PRS–500 even came with its own bookstore, Connect.com, with 10,000 titles. The PRS–500 was hailed as the gadget that would revolutionise the publishing industry: it did not.[38]

What did was an ugly duckling: the Amazon Kindle launched in 2007. The Kindle weighed more than the PRS–500, had a poorer quality screen and looked nowhere near as good.

Yet the Kindle was modelled not as a product but as a service and a system: the point was to allow people to find, buy, download and start reading books as fast as possible and to put publishers at ease with digital books. To do so Amazon sacrificed some of its profit on e–book sales to get publishers to create digital books and recouped this subsidy by selling the Kindle at a high margin. Publishers gravitated to Amazon because they knew it would protect their rights and give them a share of the e–book profits. Amazon came very late into the market for ebook readers but at the right time so far as readers and publishers were concerned.

Systems go through different phases. In some phases they are more open to fundamental change; in others they are open to incremental adjustment. Often the maximum point of leverage is when a system is in transition.

Thomas Homer–Dixon, the Canadian complexity theorist, argues systems go through periods of emergence and growth, which then lead to breakdown, reorganisation and renewal. It is the transition between these phases, when a system is moving from one state to another that offers the greatest leverage. This is when timing becomes vital to innovation. There are times when even systems that are deeply resistant to change can be reconfigured.

8. Intervene at the right point

Knowing where to intervene in a system is as important as when. Donella Meadows, one of the founders of system theory, identified different levels of leverage in systems.[39]

The **parameters** of a system, which set its limits, can be changed. A minimum wage is a parameter. So is an inflation target, an immigration cap or a capital to assets ratio for a bank. The trouble with parameters as Meadows put it is : *"People care deeply about parameters and fight fierce battles over them. But they rarely change behaviour. If the system is chronically stagnant, parameter changes rarely kick–start it. If it is wildly variable they don't usually stabilise it. If it is growing out of control, they don't brake it."* Many systems work well within the parameters set for them and yet still need change. Buffers and stocks, are part of these critical parameters and they can be increased to slow down the rate of change in a system, or reduced to increase the speed with which it reacts.

The **physical features** of a system, like a distribution network, can be changed but this is often takes time and can also leave behaviour unchanged. Newly–designed schools will not change how children learn unless teachers approach their job in a different way. Infrastructures take a long time to change: London still relies on Victorian sewers.

The information flows of a system can be redesigned to enable information to flow to where it is most needed, to improve the working of feedback loops – both positive and negative – so a system can readjust, as a thermostat adjusts a central heating systems. Simple changes to how information on energy usage is displayed, for instance, can have an impact on household behaviour, although information alone is rarely enough.

The **rules and goals** governing a system – who is allowed to do what and why – can have a huge impact on behaviour. Containerisation had a huge impact only when the technology was accompanied by changes in rules: new working practices in docks; deregulation of trucking and shipping in the US.

The **framework and purpose** governing a system provides the greatest leverage. Whole systems can be transformed by changes in ideas that reorder how people behave. Shifting from industrial systems, that transform physical resources into products and produce waste in the process, to closed–loop systems that endlessly recycle and reuse resources, is an example of such a change in framework and purpose.

One of the dangers of systems, once they become established, is that they can become self–referential and even self–interested: the system starts to set its own purpose, to serve its own ends. Perhaps the most flagrant example of a self–interested system in action was the way parts of the financial system brought about the financial crash and subsequent recession through irresponsible lending, which earned bankers bonuses but left behind a mountain of bad debt. One of the most important issues in system change is how the goals of a system can be open to challenge and change. This is a major issue in health systems where advocates of radical reform argue that health systems need to promote well–being and healthy living rather than diagnosing and curing disease. The power of doctors rests on their ability to frame health through a medical lens.

9. Blank sheets are very rare

New systems often fail when they demand everything should be changed all at the same time. Almost without exception successful new systems cleverly incorporate elements of old systems to make them easier to use, more familiar and to minimise learning. The growth of railway systems is a prime example.

Modern railway systems started life in England in the 18th century, transporting coal from collieries to canals and ports. As the coal industry grew so did colliery railways. In the north east of England adjacent colliery railways began to combine to form something like a network. As they did, it became important to regularise the gauge – the width between the rails – on which trucks were pulled by horses. From the first railways in ancient Greece and Rome, the gauge for horse–drawn carts had been between 4'6" and 5'. This width was the best for animal traction. A wider gauge would have meant the trucks would be too heavy. A narrower gauge and the trucks would have been too unstable.

When George Stephenson was appointed in 1825 as the engineer for the first public railway in England, between Stockton and Darlington, the forerunner of all forms of mass rail systems, he used horse–drawn trucks from nearby Hetton colliery to bring the earth to build the embankments. The gauge for these trucks was 4' 8". The steam locomotives that Stephenson planned to employ could have easily carried wider, heavier loads than horses, yet Stephenson adopted the 4' 8" gauge for his 'permanent way.' The changes Stephenson was proposing were already revolutionary: a steam–powered railway for public use was an untested new technology, with an untested business model. Widening the gauge was the least of their concerns.[40]

Stephenson's 4' 8" gauge was challenged by Isambard Kingdom Brunel, who employed a 7'4" gauge on his railway between London and Bristol. The 7'4" gauge provided a more stable, smoother ride and trucks could carry heavier loads. Different gauges were adopted elsewhere: wider in Russia and India, narrower in parts of Africa and Australia. Yet the 4' 8" gauge, borrowed from the old horse–drawn era in the collieries proved dominant. As writer and railway enthusiast Ian Jack, puts it : *"Of the 750,00 route miles of railway in the world today, 60 per cent measure 4' 8" from rail to rail. Across and under the Rockies and the Alps, and the Thames and the Hudson, past the cherry slopes of Mount Fuji, spreading out into webs of freight years, converging at junctions; shining and exact parallels, the reasons for their particular exactness lost to the mainstream of history."*

Stephenson was revolutionary where it mattered – showing how a public railway with a steam train could work – while being conservative where it did not matter – the gauge for the rails. Clever systems innovators know when to clothe the new in the old, to incorporate older elements into new systems to make them less threatening.

10. Learn to leapfrog

In much of the world, huge opportunities for systems innovators are being opened up by mobile digital technologies. From banking to health services innovators are developing alternative models for serving people by doing without traditional, heavy, complicated, infrastructures of hospitals and banks. These light, mobile systems leapfrog the old systems, rather than trying to reform them. The systems of the future will be created by leapfroggers.

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ANNEX

Further reading

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1 Plough Place
London EC4A 1DE

research@nesta.org.uk
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