EDISON

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- Artificial Intelligence is finally coming of age….
- …which has driven all the ecosystems to invest heavily.
- However, AI remains at a very early stage…
- …with none of the three big problems of AI close to being solved.
- Search engines lead while Facebook is the laggard.

Mobile Ecosystems

Men and boys

Sector report, February 2017

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Mobile Ecosystems

Men and boys

The difference between men and boys will be the brains of their toys. Artificial intelligence (AI) promises to substantially improve the Digital Life services offered by the ecosystems that has underpinned a period of feverish investment. Despite this activity, developments are at a very early stage with none of the big challenges of AI being close to being solved. It is the search engines that are ahead in AI followed by Apple, Microsoft and Amazon. AI remains the Achilles' heel of Facebook.

- Artificial intelligence appears at last to be coming of age. The prospect of making real returns on investment has driven all of the ecosystems to invest heavily.

- Three goals for AI. AI is still in its infancy with three big issues to be solved. These are: 1) the ability to train AIs using much less data than today; 2) the creation of an AI that can take what it has learned from one task and apply it to another; and 3) the creation of AI that can build its own models rather than relying on humans to do it. Performance in solving these three problems is likely to separate the men from the boys in the long term.

- Early days. Edison finds that most claims to AI are simply advanced statistics and that true AI is at a very early stage. Even the best have made little headway with the three goals of AI.

- Law of Robotics. There is no doubt that good quality AI has the potential to significantly improve the quality of Digital Life services offered by the different ecosystems. Consequently, Edison sees AI being a major differentiator and now includes an assessment of AI as Law of Robotics No. 8: An ecosystem must have good artificial intelligence.

- Digital assistants are the first real deployment of AI in ecosystems and are being offered free in order to generate the data that is needed to continually make them better. Consequently, digital assistants are a good first yardstick of each ecosystem's competence in AI.

- Search engines. AI still requires vast amounts of human labour, great skill and copious data to develop, which hands a substantial advantage to those that have been doing it the longest. Understanding data has been the livelihood of the search engines for many years. This is the main reason why it is Google, Baidu and Yandex that are the global leaders in AI and all of them are aggressively investing to maintain their advantage.

- Fast followers are made up by Microsoft, Apple and Amazon. Both Microsoft and Amazon have scope to earn a return on AI in their businesses that are not part of the ecosystem. Apple appears to have voluntarily hobbled its AI development with differential privacy.

- Facebook is the laggard with one of the weakest positions in AI globally. Edison research indicates that Facebook has real problems with automation. These have to be fixed otherwise providing customised services to 1.8bn users manually will be cripplingly expensive.

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Artificial intelligence

AI winter

In the field of computer science, the perfect intelligent machine is one that can understand its environment and the goal it has been asked to achieve. It should then be able to take actions that optimise its probability of success. This concept has been around for over 50 years and a series of spectacular failures in the 1980s and 1990s brought on what academics refer to as the AI winter. This was a period of low interest and falling funding. So poor did AI's reputation become that in the mid 2000s many researchers started using other terms such as knowledge-based systems and informatics to avoid the stigma that AI carried. The last 10 years has made a huge difference as mobility has come of age, with over 2.5bn users now living a good portion of their lives in the digital domain. This has created huge economic incentive to use intelligent machines to improve one's Digital Life services, which has led to a big upswing in investment commonly referred to as AI spring.

AI spring

In the last 10 years, the world has become largely digital, which has led to AI now being the hottest area of development in the technology sector. Edison thinks that this has been driven by three factors (Exhibit 1):

■ **Infrastructure.** With one or two exceptions, most of what is referred to as AI today is actually statistical analysis, which requires a large amount of data to be analysed in a short time period. Furthermore, this sort of analysis is resource intensive making it very unsuitable to be effected on a battery powered terminal. Consequently, any service or function that looks for patterns and draws conclusions based on those patterns is ideally suited to run in the cloud. The last 10 years has seen real improvements in network speeds (fixed and mobile), latency as well as processing power in the data centre. What was once a system that was too slow to be of any practical use can now upload requests, process them and download the results to the terminal sufficiently fast and effectively to be acceptable to users.

■ **Digital Life services.** The advent of the smartphone has meant that users do far more in the digital domain than they ever have before. As users begin to use digital ecosystems for more and more functions, there are other aspects emerging that impact the user experience and consequently how strongly a user will identify and prefer one ecosystem over another. Edison has previously discussed the importance of data sharing (Law 5 (Exhibit 15(b)) and data integration (Law 6) (see Mobile ecosystems – Devil in the details, page 6), but in the last 12 months AI has also emerged as a differentiator. With good AI, an ecosystem will be able to improve the quality and richness of the services that it offers to its users as well as improve the degree to which it understands their needs and desires. Consequently, in a few years' time, AI could be the difference between a good Digital Life service and one that is mediocre. This is likely to be a major driver of user preference. Edison continues to believe that it is this preference that determines how well an ecosystem can be monetised by its owner and how long it will it will last.

■ **Quantity and quality of data.** The improvements in infrastructure have gone hand in hand with a reinvention of the user experience, which has meant that use of digital services has exploded over the last six years, with users managing a good proportion of their daily lives from their smartphones and tablets. This has resulted in a huge increase in the quantity and the complexity of data being generated as a result of these services. Most ecosystems today do not make much use of this data but have recognised the benefits that could accrue to them if they have a better understanding of what their users are doing. AI is likely to be the key that unlocks this data and allows an ecosystem to draw meaningful insights about its users and thereby improve the quality of its services.

**Exhibit 1: Transition to AI spring from 20 years of winter**
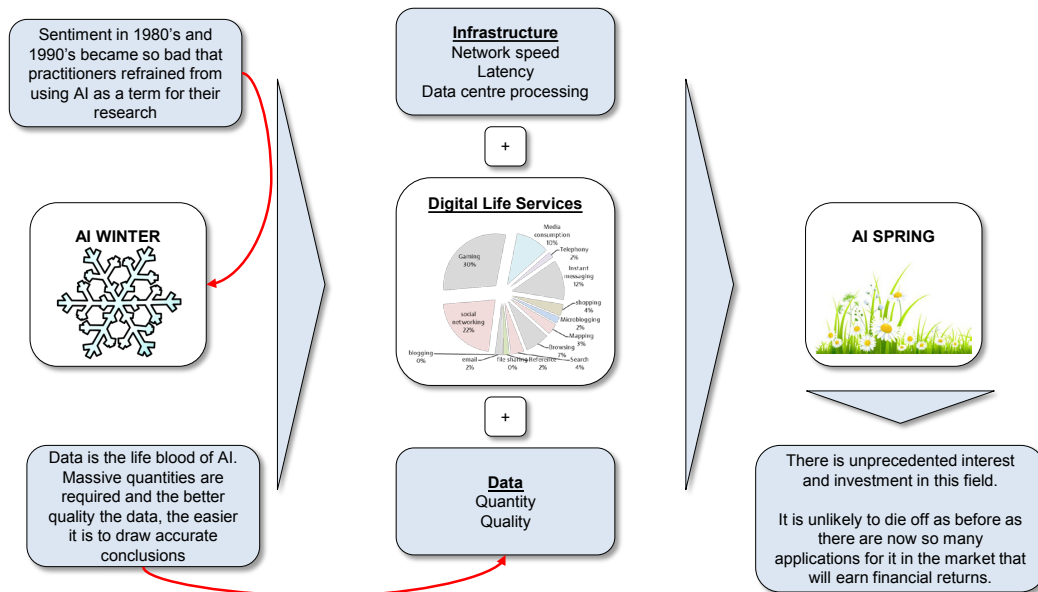
Source: Edison Investment Research

The net result is that the demand for more intelligence in mobile devices has induced what practitioners call an AI spring, with every major ecosystem ramping up investments. This does not appear to have been a revolution per se, but instead a re-awakening of interest in the potential that AI offers driven mostly by the fact that investments in AI offer tangible returns for the first time. This is because AI promises to be a fundamental ingredient in driving the consumer choice of where to live their digital lives. **Edison continues to believe that it is this choice that almost singlehandedly drives the profitability of the ecosystem companies, which have a combined market capitalisation of more than $2,000bn**.

AI can influence consumer preference because it has the potential to improve Digital Life services to the point where users experience more utility from them and consequently look for these improvements when making purchases of devices and services. **Edison thinks that, currently, AI's ability to improve these services is extremely limited**. Consequently, AI is the focus of intense development activity as the process of creating AI algorithms remains a very slow, expensive and labour intensive process.

Edison sees four stages in the evolution of AI algorithms. The first three describe the process today (AI spring) and the fourth describes what is required for AI to really come of age (AI summer) (Exhibit 2).

Exhibit 2: The seasons of artificial intelligence
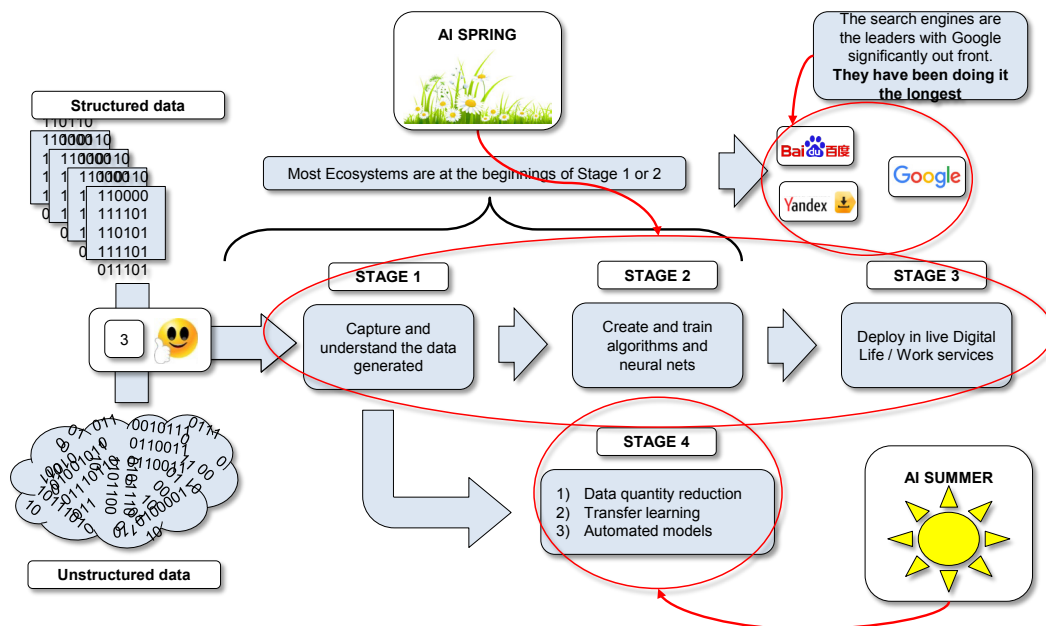
Source: Edison Investment Research

AI spring (stage 1-3)

The first stage in developing an algorithm to improve Digital Life services is to understand the data that has been captured from the services. This is what Edison refers to as stage 1 (Exhibit 2) and it is a very difficult problem in its own right. This is because 80% or more of all data generated by Digital Life services is unstructured, meaning that there are no handy meta tags or labels to tell the system what the data is and where the critical elements are located. Images, video, email, audio and so on are all good examples of unstructured data and considerable AI is required just to understand the data before any meaningful conclusions can be drawn from it. For example, a batch of photographs would need to be analysed by AI to recognise faces and objects before that learning could be run through another AI algorithm to understand the relevance of those faces and objects (stage 2 (Exhibit 2)). Once the system has understood the relevance of that data, it can use those learnings to improve the performance of Digital Life services (stage 3 (Exhibit 2)).

Data from Digital Work is easier to understand because much more of it is stored in a database format. A database is basically a big spreadsheet with labels on the rows, columns and tabs that tell the system what the characteristics of the data are and where to find it. As time goes by corporations are finding that more and more of their data is also unstructured, meaning that they also have to work out ways of understanding their data sets. This is what is referred to as big data and it will only continue to increase in importance with time.

**Exhibit 3: Stage 1 – Capture and understand the data generated**
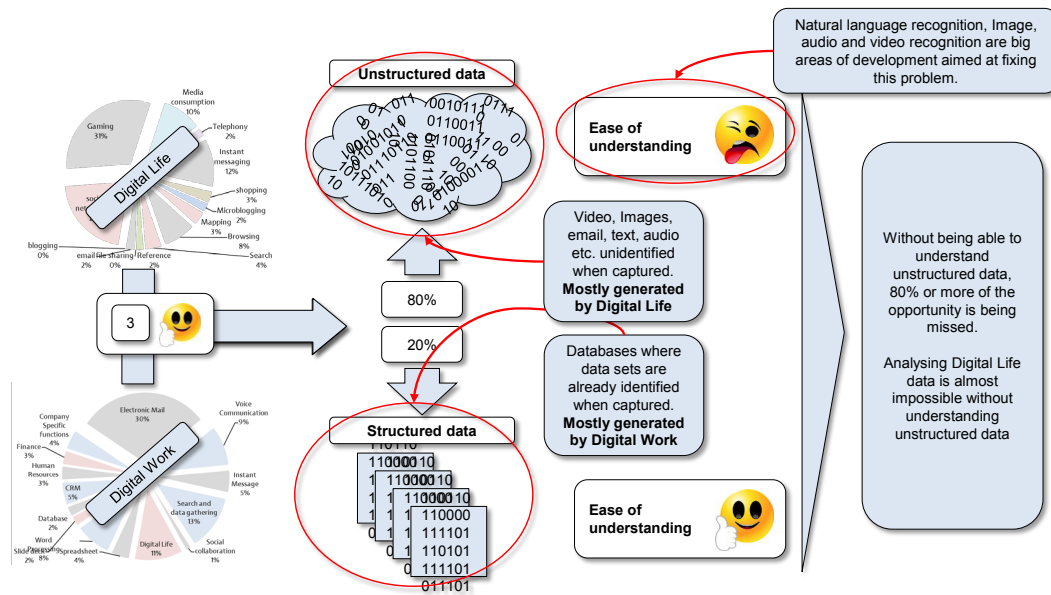
Source: Edison Investment Research

The double AI problem

On top of the very lengthy training period required for most AIs, most ecosystems will also have to deal with what Edison refers to as the double AI problem. This refers to the fact that in order to be able to use AI to improve Digital Life services, most ecosystems will have to train two sets of algorithms. This is because the vast majority of data that is being generated by consumers is unstructured data (Exhibit 3). Consequently, once the data has been captured (Law No. 3 (Exhibit 15a)), it has to be recognised and understood by the ecosystem (stage 1, Exhibit 2) before it can even begin working out what to do with it (stage 2, Exhibit 2). This is pretty much how DeepMind's AlphaGo AI (page 25) works, which uses one neural network (page 10) to analyse the board (stage 1) and then another one to work out what to do (stage 2). A simple example of this is Google Photos, which analyses photographs taken by the camera and then sorts them into albums based on how it sees the photographs being connected.

Exhibit 4: The double AI problem
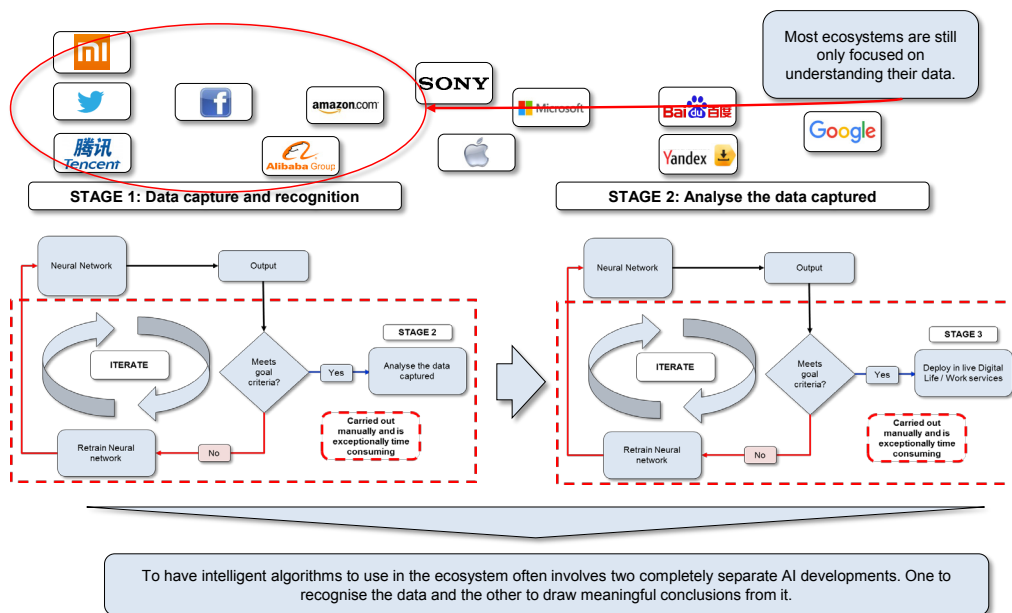
Source: Edison Investment Research

In this example one AI must be trained to recognise faces, features and objects in the photographs (Exhibit 4, left-hand side) and then another AI is needed to work out what the relationships are between the people, objects and places that it has identified (Exhibit 4, right-hand side) and then sort them accordingly. **Furthermore, to train stage 1, a large quantity of data is required meaning that the ecosystem has to find a way of getting users to engage with its AI long before its development is complete. This is where the digital assistants (page 11) come in, which are the first real iteration of AI to the user**. Edison thinks that to enhance most Digital Life services, most ecosystems will need to complete training of both sets of AIs, which will only lengthen the development time in getting enhanced Digital Life services to market.

When the ecosystems are examined, it very quickly becomes clear that most are at a very early stage of development. This is because the attention of many remains firmly focused on stage 1 only (Exhibit 3). Once these ecosystems can understand their data, they still have to move onto stage 2 and work out what to do with it. This is where search engines Google, Baidu and Yandex have a huge advantage. Not only to they collect vast amounts of data with which to train their AIs, but they have also been working on this by far the longest. It is really only the search engines that are advanced enough in their understanding of the data that are able to start using it to enhance their services. Once again, this analysis indicates that AI is the Achilles' heel of Facebook (page 46) as it remains far behind the search engines, Microsoft (page 40) and Apple (page 36). Amazon (page 43) is a slightly different case as its core businesses of e-commerce and cloud could benefit very quickly with the ability to recognise natural speech, images and video.

AI summer (stage 4)

Edison research indicates that the sudden demand for AI is based on the realisation that the intelligence of Digital Life services could mean the difference between success and failure. Unfortunately for most players, AI is still very much in its infancy with most "intelligent" systems being driven by large-scale statistical, brute-force (page 8) analysis rather than a system that is truly intelligent. These statistical models are built and trained by humans and require vast amounts of data, meaning that they take a very long time to create. This means that, currently, those that have been working on these models for the longest have a huge advantage. Therefore, the search

engines currently lead the industry as these kinds of models have been the bread and butter of the search engine companies for many years. This is why Edison thinks that the best AI is to be found within those that offer search functionality such as Google, Baidu, Yandex and to some degree Microsoft.

Exhibit 5: The signs of AI summer
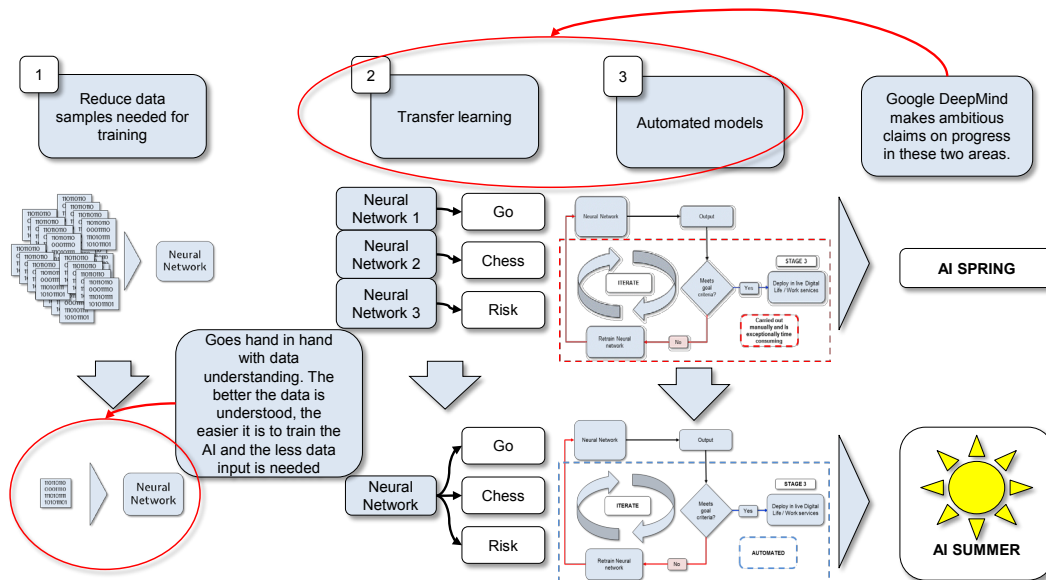
This is where the industry is today. AI spring is here and a lot of resources are being poured into AI, but in terms of the services, progress is slow. Edison believes that three things need to happen for AI to really come of age (AI summer) but it is still going to take a long time to get there. **As one practitioner appropriately explained it. "The only thing that is as true today as it was 35 years ago, is that we will see true AI in about 25 years"**. Edison thinks an AI summer requires the following:

First: Data quantity reduction. Today, vast amounts of data are required to train AI models, which has a huge impact on the amount of time that it takes to get good results as well as the speed to which it can adapt to changing circumstances. AI models today require both millions of data points and extensive manual training to master simple tasks that small children can complete with a very small number of data points. This requirement needs to be reduced massively so that the time and cost it takes to train and adapt models can be greatly reduced. This would make it easier for new entrants to erode the lead of those that have been working on their models for a long time but there is little sign of this today. **Edison thinks that data capture and understanding (Exhibit 3) is a core element in reducing the volume requirement.** The better the system understands what the data is that is being used, the easier it will be for the model to adapt and arrive at the right conclusion.

Second: Transfer learning. This refers to the ability to learn to solve a problem in one domain and then apply that logic in another application. Currently, a separate AI needs to be built for every single task and none of the learnings are transferable. For example, the AlphaGo (page 25) machine is probably the best Go player in the world, but it cannot play Chess even though some of the principles behind these games are the same. This remains true even if the AlphaGo machine was taught the rules. This significantly limits the usefulness of any AI engine that is built, and transfer learning remains one of the major goals of advanced AI. DeepMind AIs can learn how to

play simple 1980s hand–eye co-ordination video games with no manual training but struggle with anything more complex.

Third: Automated models. Currently, AI systems are built, trained and maintained by humans, which is very expensive and time consuming and requires a lot of skill. The ideal situation is one where the system is given a problem and can then build and train the models itself. This would have the effect of greatly reducing both the time required and the expense of creating and maintaining intelligent machines. This would allow AI to be far more useful and widespread than it is today, probably representing one of the biggest steps forward for many decades.

Edison thinks that this represents the most important step forward of all three stages and would in all likelihood be the most difficult of the three to achieve. It is this kind of intelligence that would bring us closer to the dystopian futures envisioned by *Terminator* and *The Matrix*. Practitioners are already designing fail-safes and kill switches to prevent these sorts of events from ever coming to pass.

Beyond summer and Pandora 's box

Many practitioners and theorists in the field think that the advent of AI summer will be rapidly followed by artificial general intelligence (AGI), which refers to the point where a computer brain becomes at least as intelligent as a human. This belief is driven by the exponential rate at which AI has evolved over the last 100 years and extrapolating that forward (Exhibit 6). AI has already been able to mimic the neuron pathways of a flatworm, which has 302 neurons, and is on the upward path towards the human brain, which has 100bn connections. Using the exponential pace of AI development, expert thinkers in the field estimate that AGI could be reached sometime around 2040.

It is at that point that all bets are off, as by that stage AI will most likely be able to self-improve and there is no reason why it should stop at a human's level of intelligence. This means that AI could very quickly become vastly more intelligent than humans. This is what the AI field refers to as artificial superintelligence (ASI) and it is at this point that all ability to predict what would then follow irretrievably breaks down. This is because an ASI would most likely to be able to out-think any safeguards that its creators have put in place to keep it under control. It would be like a chimpanzee trying to outwit a human except that this time it would be the humans that are the chimpanzees. In effect, humans would have ceded control of planet Earth to the ASI leaving our species completely at its mercy. **Fortunately, this Pandora's box is many years away from being opened, even with exponential growth in AI.** Consequently, this report will focus on the outlook for digital ecosystems over the next 10 years rather than the possibilities of a dystopian future and existential threats to human existence (although this is a popular topic).

Exhibit 6: Beyond summer and Pandora's box
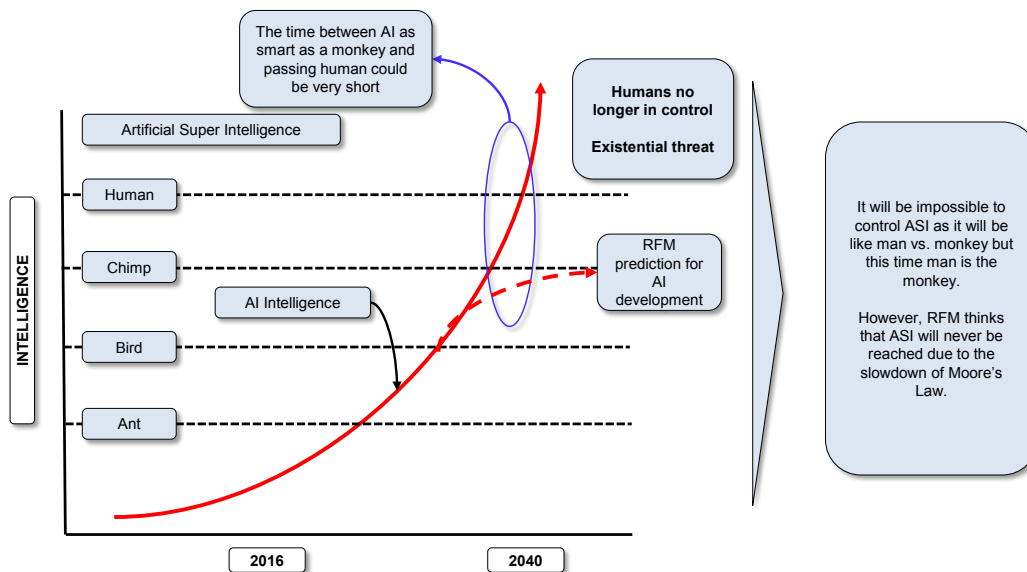
Current status

At the heart of most of what is referred to as AI today lies large-scale automated statistical analysis. A system collects vast amounts of data upon which it can perform sophisticated statistical analysis, from which it is then able to make predictions that are more likely to be right than wrong. **Furthermore, Edison thinks that a lot of problem solving still uses a "brute force" approach, which is extremely slow and can consume vast amounts of resources**. Brute force involves an algorithm that tests all possible outcomes and then selects those outcomes that best fit the designated solution. This approach is acceptable for simple tasks such as working out a simple route or playing a rules-based game, but the kinds of problems that AI is now required to solve make this approach increasingly obsolete. Google's DeepMind claims to have created an AI that is significantly closer to AI summer by being able to learn once and apply elsewhere as well as being able to learn without models (ie it builds its own). For a longer discussion of DeepMind see page 25.

As problems become more complex, the range of possible outcomes very quickly becomes unmanageable, meaning that refinement is required to allow the problem to be solved quickly enough to be useful to the user. Open-ended problems like facial recognition or natural speech require a much more sophisticated approach, which is where the building of neural networks becomes important.

Neural networks

A neural network is a computational system aimed at solving problems in a way that is highly scalable and much more efficient than "brute force" (see above). The design is loosely based on how the brain is structured (hence the name); the brain has many neurons that are connected to each other and pass signals back and forth. In their simplest form, each neuron represents a mathematical transaction that is applied to the characteristics of the data that has been captured. The result of each operation is passed on to the neurons to which it is connected, which then perform an operation on the result and pass it on. Neurons tend to be organised in layers (Exhibit 7), with the neurons connected to other neurons in adjacent layers rather than those in more distant

layers. This creates a structure around which a logical process is more easily constructed. The last layer of neurons produce the output, which can then be assessed.

Exhibit 7: A neural network – 1

Exhibit 7 shows a neural network immediately after it has been built but before any data has been run through it. Once the network has been built, data is allowed to flow through the network and the result analysed. If the result is not a solution to the problem, then the weights of the connections between the neurons are automatically adjusted (Exhibit 8) and the data is passed through once again. In essence, this is a form of iteration and in the simplest examples, the output either converges on the solution as the weights of the connections are dynamically adjusted or it will get stuck. When it gets stuck, a human needs to intervene. The neural net needs to be manually changed by adding or subtracting neurons, changing the layers or changing the data characteristics that are used to compute the solution. Knowing what to adjust and how is a highly skilled task that takes many years to learn. Once the changes are made, the system is run again in the hope that a solution will be found.

The restructuring of the neural net is currently a manual process (Exhibit 7) carried out by humans, which is a major reason why training AI algorithms is such a lengthy and expensive business. This is also why a major avenue of research is to teach the machines to create and adjust the models themselves because then the algorithms will be much quicker and cheaper to train. **Edison thinks that this is a very long way from becoming a reality and is one of the three signs of the arrival of the AI summer (Exhibit 5).**

**Exhibit 8: A neural network – 2**
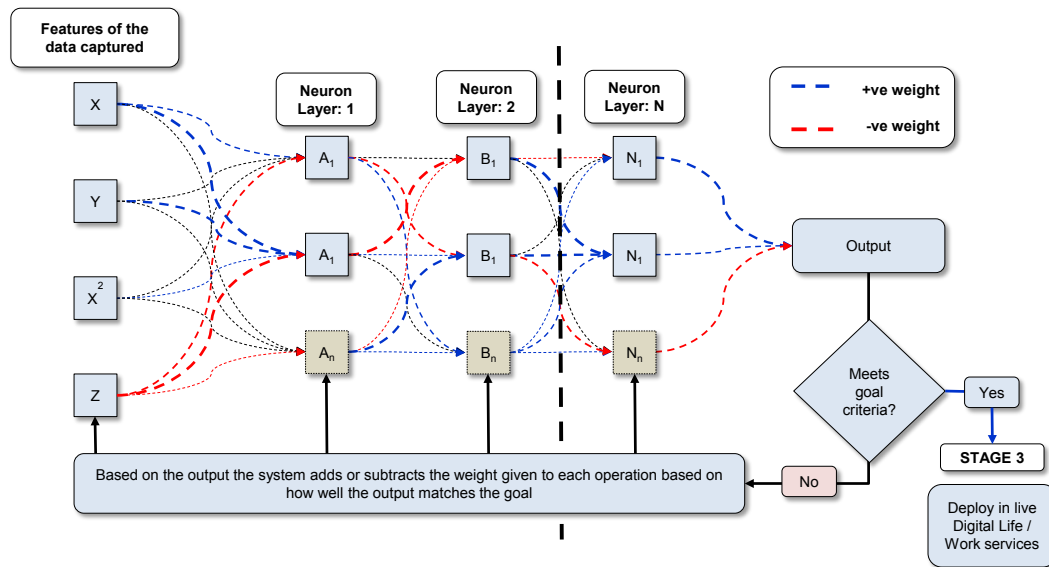
Source: Edison Investment Research, Tensorflow

Digital assistants: Artificial intelligence 1.0

The digital assistant is the first real service to be offered to ecosystem users that is completely dependent on artificial intelligence to offer a good quality service. This began with the ability to search the internet using voice rather than text and has gradually evolved from there. Apple was indubitably the first (2011) to migrate this into a service, but it is Google that Edison thinks has the real edge (see Alphabet page 23). The idea is that this will become as useful and dynamic as having a human assistant, creating a reason for users to choose one ecosystem over another.

Exhibit 9: Artificial intelligence 1.0 – digital assistants
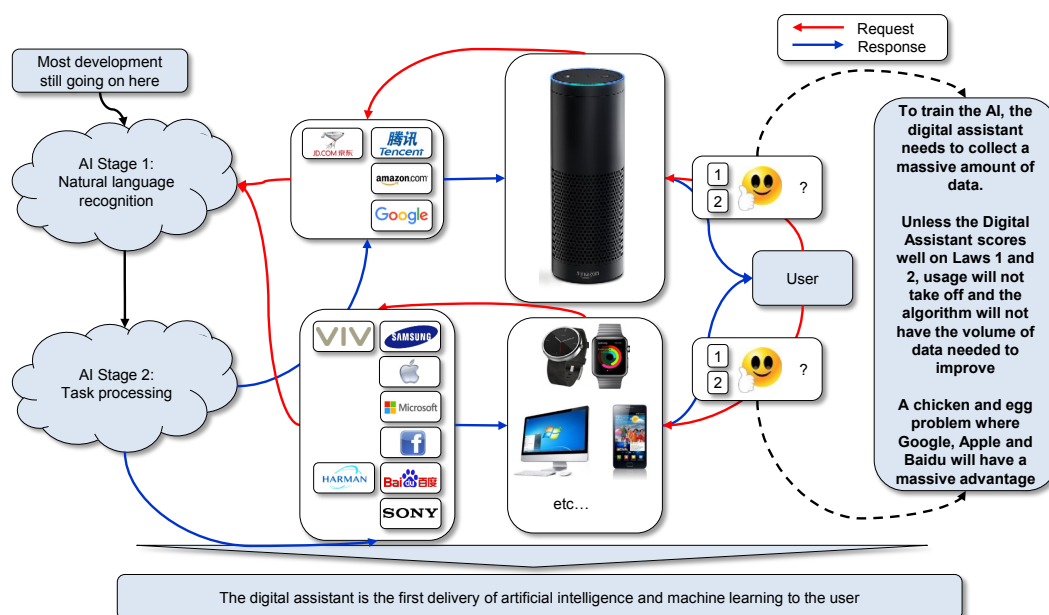
Source: Edison Investment Research, company data

Currently, all of the top ecosystems have a personal assistant that is being delivered through two main device categories, the mobile phone and the home speaker. The home speaker opportunity

was opened by Amazon with its Echo product, but as this category lives and dies by the quality of the AI being offered, Edison thinks that others have an opportunity to displace it. Top of this list is Google Home as it has, in our view, by far the most advanced AI (Exhibit 10), which should enable it to offer users the best experience.

Digital assistants are predominantly designed to interact with the user using speech, such that they can more closely emulate the ease of communicating with another person. Consequently, AI is needed to solve both the problem of stage 1 and the problem of stage 2 (Exhibit 4).

It is the solving of just stage 1 that is occupying most of the current development, as most digital assistants struggle to understand natural speech and follow on questions are almost impossible unless they have been pre-programmed. The one that makes the boldest claims here is Viv, which was created by the original founders of Siri before it was purchased by Apple. Viv claims to be able to handle complex, multipart and follow-on questions, which is something that none of the other assistants have come close to. The problem is that no one has been able to really test Viv as it has only been shown under demonstration conditions. Assuming it lives up to its billing, it represents a big step forward in solving the problems around stage 1. With their huge pool of user data, Google, and to some degree Facebook, would have made a good fit for Viv, but it has ended up in the hands of Samsung. Edison finds this to be a strange outcome as money is very unlikely to have been the deciding factor. Edison thinks that the founders want to remain as platform agnostic as possible as well as have an enhanced opportunity to address other areas of the smart home. This creates a rationale for being owned by Samsung, but without access to large amounts of user data or expertise in the AI for stage 2, it is difficult to see how it can progress beyond natural speech recognition.

Chicken and egg problem

Digital assistants are at an extremely early stage and are not even remotely close to approximating human intelligence or even outwitting a young child. Consequently, these assistants are designed to alleviate the user of the easy, humdrum tasks such as finding a route, effecting a search or creating reminders and calendar entries. The digital assistants are starting simple because **to improve, they need to be used, as all AI algorithms need vast amounts of data to evolve**. This creates a difficult chicken and egg problem, as a digital assistant needs to register a good score on laws 1 and 2 (easy and fun user experience, page 19) to generate usage, but at the same time will have difficulty in becoming useful without the data needed to train them. This is why the digital assistants are starting at a very basic level where in many cases they offer little more than voice control of apps or a straightforward search.

Exhibit 10: Digital assistants assessed against Laws 1 and 2
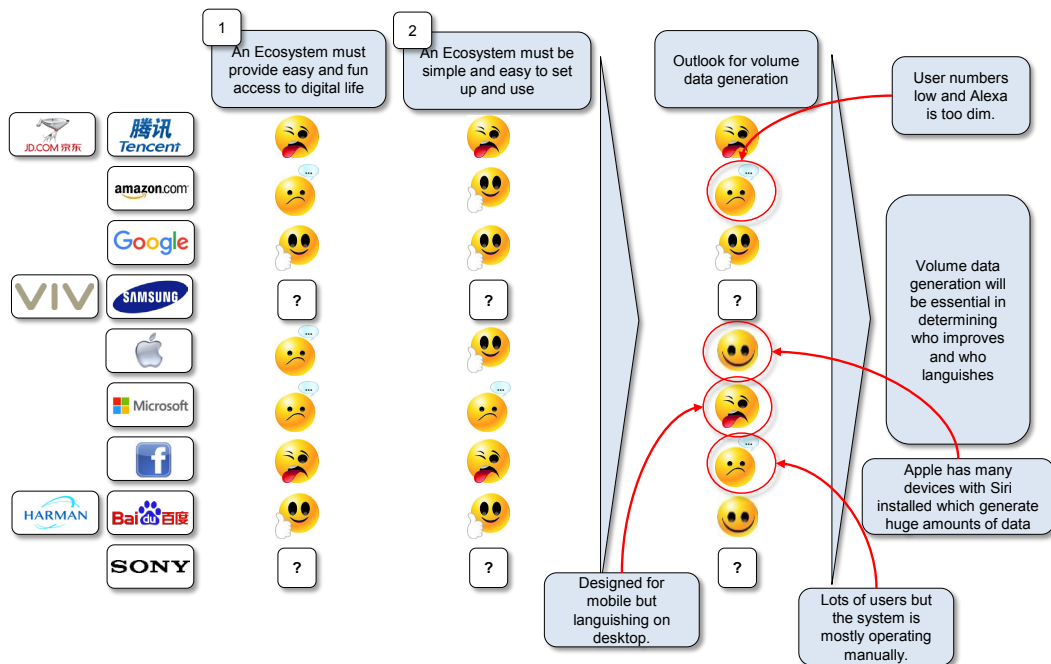
Source: Edison Investment Research

When it comes to data generation, Edison sees Google, Apple and Baidu as having the biggest advantage. Google and Baidu have an edge because they already generate vast amounts of data with their search and have the best AIs (Exhibit 10). Consequently, as they can offer the best user experience, they are likely to be used the most and therefore evolve and improve more quickly. Apple's Siri also has an advantage for two reasons. **First,** it is present and set as default on the devices of over 400m users. **Second,** those devices generate far more traffic than an equivalent android device, presenting Apple with a great opportunity to train Siri. To date, Edison thinks that this has not been very effective as it continues to see Siri on par with Cortana (Microsoft) and way behind Google.

Digital assistants outlook

It is clear that digital assistants are the first area where AI will be the real deciding factor in a Digital Life service. Hence, they serve as a good yardstick for where each ecosystem is in terms of how advanced and mature its AI algorithms are. Thus, Edison has used digital assistant performance (Exhibit 10) as an early measure of how advanced the ecosystems are in terms of AI (Exhibit 14). Despite the differences between them, it is clear that all of the ecosystems investing in AI are at a very early stage and most are still grappling with stage 1, let alone being ready to move onto stage 2. This will be an area of fierce competition for a long period of time.

Digital life

The Edison Investment Research Digital Life pie (Exhibits 12 and 13) remains central to our analysis of the digital ecosystem. It measures how much time users spend engaged with digital services on their devices (excluding voice, text and e-commerce.) Analysing each ecosystem on this basis gives a very good idea of how well developed its strategy is and how much more work or investment is needed to assemble the right assets to provide a complete offering for the user's Digital Life. It also gives a good assessment of how big the monetisation opportunity is. An assessment of the impact of Digital Life on the monetisation opportunity is discussed in detail in Mobile ecosystems, Money talks, page 3.

Device types

Edison views all devices with a digital capability as a conduit by which the digital ecosystem can be delivered to the user. With the explosion of device types each designed with a different use case in mind, some devices are better at certain services than others. Therefore, every device category will have a different Digital Life pie in terms of the share that each service takes of the user's time when they are engaged with that particular device. The best example of this is the tablet where the larger screen provides a better medium for playing games or media consumption. This explains why those two segments are much larger in the tablet pie than on the smartphone..

Exhibit 11: Ecosystems across different device types
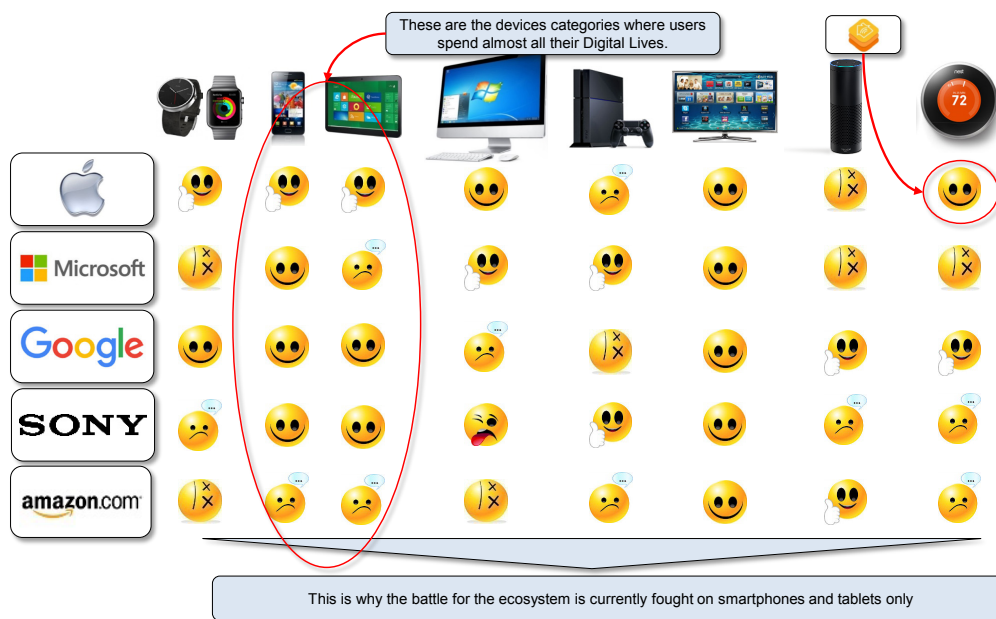
Source: Edison Investment Research, company data

When it comes to the analysis of the ecosystem, Edison believes it is the only the usage of devices upon which users base their purchase decisions that should be considered. Other devices that deliver the Digital Ecosystem but have no bearing on the user's decision about where they live their Digital Life are not considered relevant. For example, a user does not buy an Apple watch to live his Digital Life with Apple. Instead they buy an Apple Watch because they are already a member of that ecosystem. **Furthermore, the usage of these devices is not nearly great enough to be a major influence on the purchase decision, which is why usage outside of smartphones and tablets is still not included in the Digital Life analysis**. Edison anticipates a time when these devices become increasingly important and when their usage is high enough to influence the purchase decision, they will be included in the calculation of the weighted average Digital Life pie.

It is the anticipation of the importance of other device types that has the ecosystem players all developing products to help them to deliver their Digital Life services to their users. Furthermore, offering their ecosystems across a range of devices gives the providers an opportunity to use the experience on one device to sell the experience on another. As long as the experiences are consistent and seamless (Law of Robotics No 7, page 19), this has the potential to deliver premium pricing to these products driven by the user's preference to purchase a device to remain within the ecosystem of his choice (monetisation by hardware, see Mobile ecosystems, Money talks, page 3). The next product category most likely to be relevant in the purchase decision is the home speaker, because this has become a major conduit for the delivery of a digital assistant to the user as well as offering the potential to become a gateway for managing other smart devices in the home.

Exhibit 12: Edison Investment Research Digital Life pie, Q316

Smartphone vs. tablets % total time used

Weighted average Digital Life Pie

Smartphone Usage 80%
Tablet Usage 20%

Tablet usage is suffering from declining share. Larger screen devices mostly to blame. Down to 20% from 24%

Gaming 30%
Media consumption 10%
Telephony 2%
Instant messaging 12%
shopping 4%
Microblogging 2%
Mapping 3%
Browsing 7%
Search 4%
Reference 2%
file sharing 0%
email 2%
blogging 0%
social networking 22%

Gaming and Social Networking are the biggest but Media Consumption and Shopping are the fastest growers. IM slowing

Source: Edison Investment Research, Nielsen, Google, Pewinternet.org, CommScore, NetMarketShare

Digital Life services grow at different speeds, which is why the last few quarters have seen some changes in the makeup of the Digital Life pie. The segments that have lost share are not declining. They are simply growing more slowly than the others (Exhibit 12).

Over the last few quarters, tablet usage has begun to noticeably decline as a share of the total when compared to smartphones. This is due in part to the weakness in the tablet market but also because large-screen phones continue to increase their share of the smartphone population. The end result is that users are less inclined to own both devices and a large-screen smartphone device will often suffice. Larger-screen devices, greater usage of on-demand services as well as easier payment have also led to shopping becoming more popular in smartphones. Edison thinks that it is now the fastest growing segment of the Digital Life pie although it remains tiny when compared to China (which is at 12%; see Radio Free Mobile's China Ecosystems, BATmen – written by Richard Windsor, the author of this report – page 12, Fig 9). Gaming and browsing are now growing much more slowly as they have been reasonably well developed for some time.
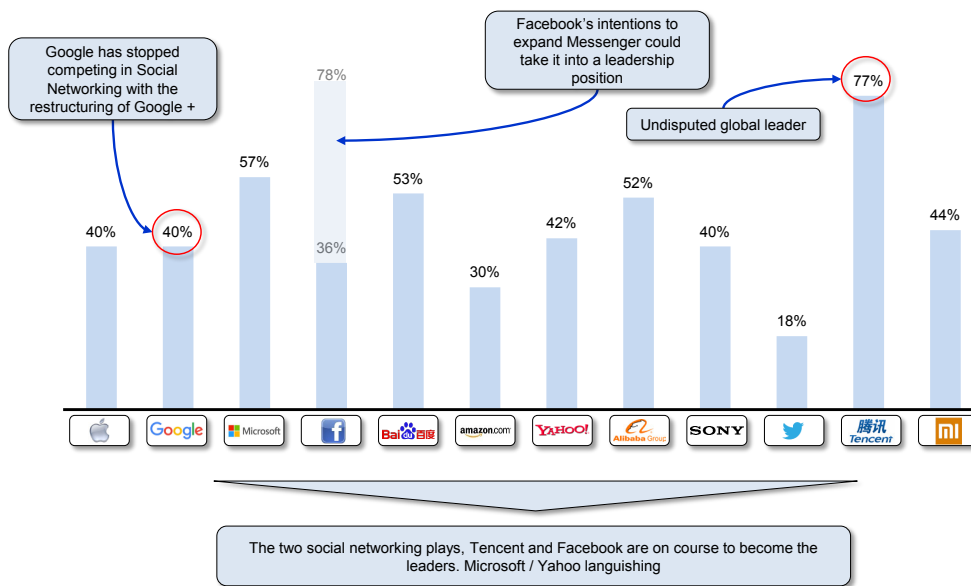
Source: Edison Investment Research

In terms of ecosystem coverage, Edison has made some changes to its universe. BlackBerry and Mozilla have been removed as neither show any intention of competing as an ecosystem to be replaced with the BATmen (**B**aidu, **A**libaba and **T**encent). The ecosystem and outlook for the BATmen has been discussed in detail in Radio Free Mobile's China Ecosystems, BATmen, and will not be discussed here other than to compare them to the other nine or in the assessment of their AI capabilities.

Over the last six months, the rest of the coverage picture has remained reasonably stable but the addition of the BATmen is an indicator of how far they are advanced at home and what threat they could pose overseas. Edison does not think that many Chinese services are applicable overseas but **experience in operating at scale and rolling out new services could be invaluable should the Chinese begin to take the overseas opportunity seriously**. Tencent and Facebook are the two ecosystems to watch in terms of emerging ecosystems, while Google remains by far the best at understanding and monetising the traffic that it does generate.

Eight laws of robotics

While the Digital Life analysis assesses ecosystems on the degree to which they are addressing the opportunity, it makes no assessment of how well they offer their services. This is where the Laws of Robotics come in. These are simple tests designed to appraise the quality of the ecosystem and how likely it is to succeed. Combined with the Digital Life pie, these laws form the basis of the estimates that Edison makes with regard to users, revenue, profit generation and the value of any one ecosystem.

With the increasing importance that AI is going to have when it comes to evolving and improving the quality of Digital Life services, it is pertinent to include an assessment of AI within the Laws of Robotics. **This has led to the creation of Edison's eighth Law of Robotics: artificial intelligence (AI) (see below).**

The eight laws are divided into two groups. The first four are the fundamental assessment of how well an ecosystem caters to the requirements of its users and a major determinate of its ultimate success in generating a return for its stakeholders. **Laws one to four are:**

1. Easy and fun: An ecosystem must provide easy and fun access to digital life
2. Set up: An ecosystem must be simple and easy to set up and use
3. Traffic capture: An ecosystem must capture traffic on its own servers
4. App equivalency: An ecosystem must offer access to a good range of third-party apps

Laws four to eight are an assessment of how well an ecosystem is set up to compete in the longer term. These are more subtle and assess the internal systems of the ecosystem to ascertain how well it can improve its services and make its offering deeper and richer for the user. Edison argues that a good score on laws five to eight is required to be able to fend off the increasing competition that will inevitably materialise as the growth in user numbers begins to stabilise. **Laws five to eight are:**

5. Data sharing: An ecosystem must allow Digital Life services to share data
6. Data integration: An ecosystem's user data must be integrated
7. Software consistency: An ecosystem must have consistent device software

Adding for the first time:

8. Artificial intelligence: An ecosystem must have good and effective artificial intelligence.

The assessment of each ecosystem against this law is based on the performance of a personal digital assistant that is freely available for users. Edison has chosen these criteria because this is the first real iteration of using AI to drive differentiation for the user. Where there is no digital assistant, Edison has looked at other services where AI is used to drive differentiation in Digital Life services. This is a much more difficult assessment to make and consequently does not provide as good an assessment as a digital assistant. Of the 12 ecosystems Edison currently sees eight that have a digital assistant available leaving Twitter, Xiaomi, Alibaba and Yahoo as the only players without one (Exhibit 9).

8 An ecosystem must have good and effective AI

Siri: Basic service that struggles with anything that has not been pre-programmed.

Google Assistant: We believe the most advanced and most useful. Google Home a threat to Echo

Duer: Early days. Should be good as it relies on Baidu's ability to parse web data. Best in China

No assistant and has made no real play in AI. Focus still appears to be on the Digital Life pie.

Facebook M: Requires humans to offer any quality of service. This is Facebook's Achilles heel.

DingDong: Tencent owns 15% of JD.com. DingDong is basic and has trouble with speech recognition.

8 An ecosystem must have good and effective AI

Cortana: an average service designed for mobile languishing on desktop. Usage is low.

Alexa: Achieved penetration with Echo device but service is behind Google, Apple and Microsoft

Search outsourced to Microsoft. Edison suspects work on AI has long ceased.

Xperia Ear: Untested. However, Sony's long heritage in robotics may help it get a step up in AI.

Twitter's social graph is very accurate due to users actively following topics rather than AI

Launched a digital assistant in 2014 (MIUI 6) but has since vanished. We believe Xiaomi cant afford AI

Source: Edison Investment Research

When an initial assessment is made, a clear picture emerges: **those with experience in search tend to be the most advanced.** This is because the ability to understand inputs as well as crawl and digest web data has been at the heart of their businesses since the day they launched, which in most cases was 20 years ago. Consequently, it is the search engines that have been working on this the longest and, as Exhibit 14 shows, time is a big factor in AI because of the amount of data needed to reliably train the algorithms.

Microsoft does have a search engine but it is ranked by Edison as mediocre when it comes to AI. Digging a little deeper reveals the reason for this. **Bing, Microsoft's search engine, has only been available for seven years compared to 20 years for Google, 13 years for Baidu and 20 years for Yandex**. Until advances in AI allow algorithms to be trained with much less data (one of the signs of AI summer (Exhibit 5), the time that the algorithm has been working will be a key factor in determining how good it is. Edison thinks it was DeepMind's focus on cracking the other two problems of AI (transfer learning and automated models, Exhibit 17) that was behind Google's purchase of DeepMind for $500m in 2014. **Should DeepMind deliver on its promises, Edison thinks Google will have bought itself a bargain (page 25).**

Edison thinks the time required to train AI as well as the inability to transfer learning from one system to another is what lies behind the recent boom in AI-related acquisitions. The fact that everyone has now woken up to the fact that AI will be a major differentiator in the ecosystem going forward has made AI start-ups the flavour of 2016. This has resulted in a huge upswing in M&A activity. There is no sign of this abating and it is those with the deepest pockets such as Google, Amazon, Apple, Intel and so on that are heading the M&A activity table. Edison suspects this will continue in 2017, so the best AI will soon be found inside the largest and richest companies.

Edison's assessment of the top six ecosystems against all of the eight Laws of Robotics can be found in Exhibits 15a and 15b. The remaining six are assessed in Exhibits 38(a) and 38(b) on page 52.

In updating its analysis, Edison makes the following observation that reflect changes in strategy, changes in performance, outlook as well as the addition of law eight. These are:

- The leaders in AI (Google and Baidu) also tend to understand the importance of data sharing within the ecosystem (laws five and six).

- AI is rapidly emerging as Facebook's Achilles heel. It has not appeared as a major acquirer of AI start-ups although Edison research indicates it is organically hiring AI expertise. Facebook's quality service tends to decline substantially as soon as automation is introduced.

- Microsoft's neglect of its consumer ecosystem has reduced the relevance of its user experience on mobile devices which has also resulted in falling developer commitment. Hence Edison has downgraded Microsoft against laws one, two, four and six. Microsoft remains the most consistent when it comes to running on different device types; see Exhibits 38(a) and (b).

- Amazon's Alexa has been first to market via its home speaker but is very far from offering a useful and intuitive user experience. With much cleverer competitors coming into the market at lower prices, Edison sees Echo struggling for penetration in homes that do not use Amazon Prime. Even Amazon Prime homes may be at risk unless Alexa improves; see Exhibits 38(a) and (b).

Exhibit 15(a): Laws of Robotics one to four for the top six ecosystems
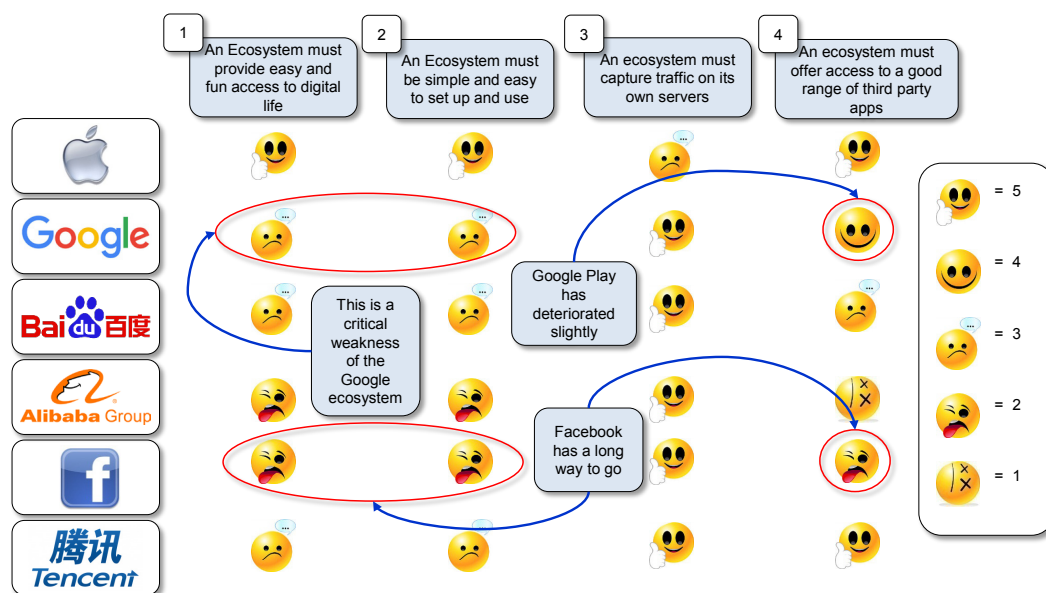
Source: Edison Investment Research

**Exhibit 15(b): Laws of Robotics five to eight for the top six ecosystems**
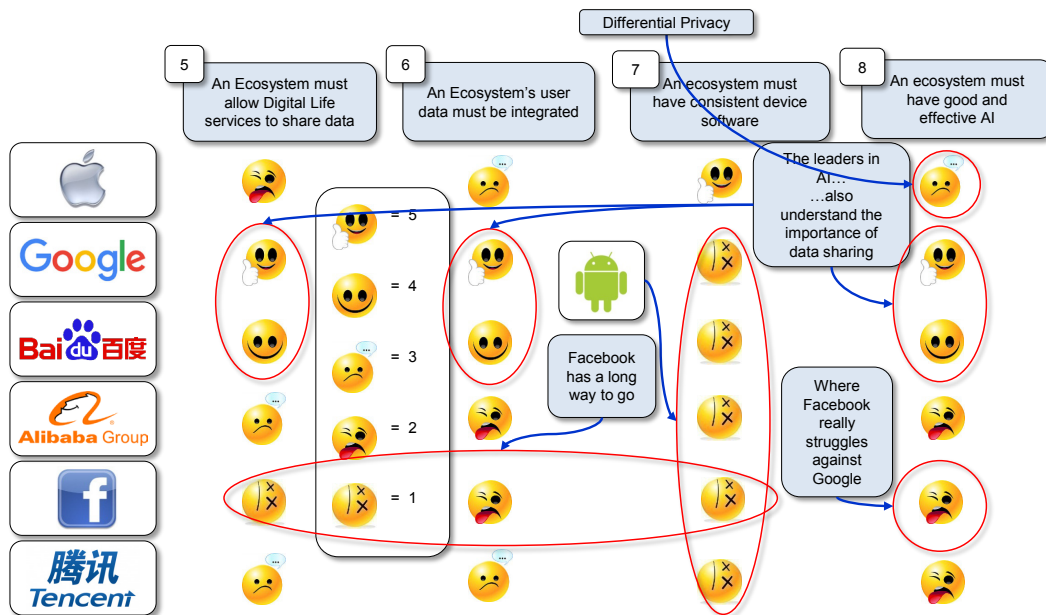
Source: Edison Investment Research

Ecosystems

Performance against the Edison Digital Life pie and the eight Laws of Robotics is used in combination with device shipment forecasts to estimate the size of the ecosystems. **Edison believes the size of an ecosystem is the single most important measure of how much value it can create for its owner.** Furthermore, the relationship between size and value is non-linear. Ecosystems are networks and so their potential to create value conforms to Metcalfe's Law of Networking, which states that the value of a network is proportional to the square of the number of connected users of the system. Consequently, it comes as no surprise the ecosystems that make all of the profit are also the largest (Exhibit 16). Edison estimates the current size of all the ecosystems and forecasts how they will evolve over the next three to five years.

Exhibit 16: Ecosystem users by provider, 2018e
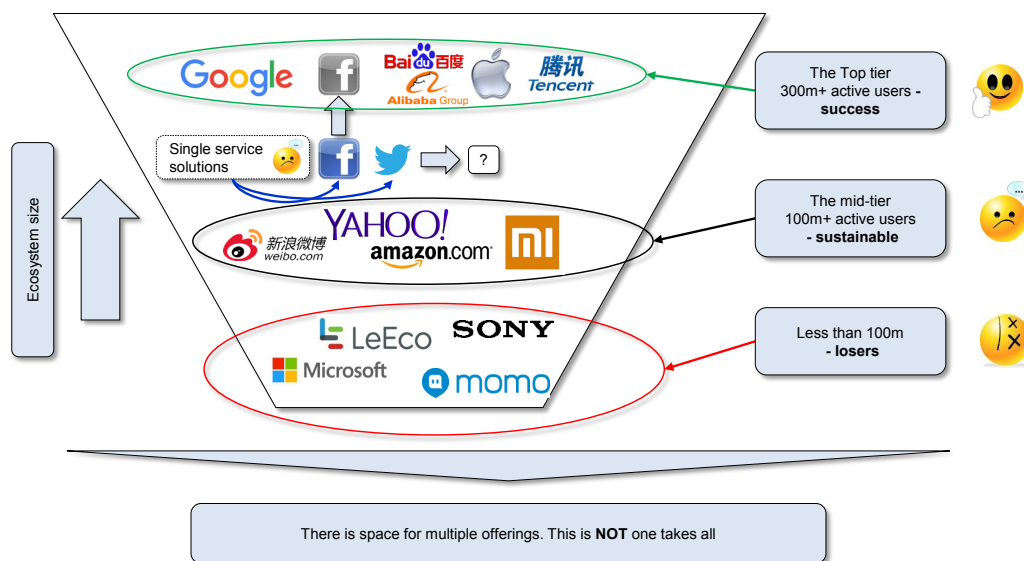
Source: Edison Investment Research, Counterpoint Research

The addition of China to the ecosystem universe has confirmed Edison's assumptions with regard to what constitutes a successful ecosystem as opposed to challenging it. Edison continues to believe that at least 100 million users are required for an ecosystem to be viable and 300 million or more are needed to make a good return on investments. Using these criteria, there is enough space, in theory, for 10+ ecosystems to survive. In practice, there are likely to be between five and seven successful, profitable ecosystems with over 300 million, several with over 100 million and a large group vying to make it into the big league.

It remains very unlikely that one ecosystem will dominate. iOS caters for the high end while Google is much stronger in the mid-tier in developed markets. China is a market dominated by the local companies and the opportunity there is big enough for three to succeed without having to look overseas. However, with the valuations that these companies now command, they cannot afford to be content with the local market and Alibaba particularly is already casting its eyes to the overseas opportunity (see Radio Free Mobile's China Ecosystems – BATmen, for more details).

Alphabet

Alpha male

Alphabet's position in AI is undeniably world leading. Search has been the bread and butter of this company for 20 years and the ability to understand 70bn items without hiring millions of people requires good AI. This is evident when one compares the accuracy and relevance of Google searches to those of its competitors. What also makes its search stand out is its almost uncanny ability to know what it is the user is searching for even if they misspell the term or in some cases omit it completely. This is an excellence that has been built up through 20 years of grinding data through the algorithm as well as understanding its users to the best of its ability.

This competence forms the backbone of Google Assistant (page 28) and is why it comfortably outperforms all others when asked reasonably straightforward, single-part questions. However, in the future, the system needs to be able to understand natural speech and be able to deal with context. For example, the request for flight times to New York should be able to be followed up by "OK book me on the 17th" with system knowing exactly what is being asked. It should then be able to suggest hotels or realise that the user has a friend living in New York where they have been before and ask if they will be staying there. Natural voice recognition and reproduction is so important as it is a fundamental building block of a good user experience that will generate the data to allow the service to improve further. This explains why Google is investing so much time and energy in getting it right.

Addressing the three issues of AI

Edison sees Google Assistant as just the first iteration of Google AI and in the background, there is active development being carried out to address the three big problems of AI (Exhibit 5). Edison sees the first of these (reduction of data needed) being addressed through the development of Google's core search algorithm (Exhibit 17: bottom). This also goes hand in hand with being able to better understand the data being generated by natural language understanding, image and video recognition and so on. The better the understanding the AI has of the data generated, the easier it will be for the system to build the right weights for its pathways (Exhibit 8) and hence the less data that will be required. Consequently, Edison sees Google's development of its core search algorithm and its work on data recognition and understanding going hand in hand. Google has been pouring data through its search algorithm for 20 years, which puts it in a very good position when it comes to both understanding the data that it collects and reducing the amount of data needed to train its AIs and keep its services ahead of its peers.

The other two problems are far more complex to solve and this is where the developments being made at DeepMind could be used to evolve the entirety of Google's AI offering.

**Exhibit 17: Edison view of Google's approach to AI summer**
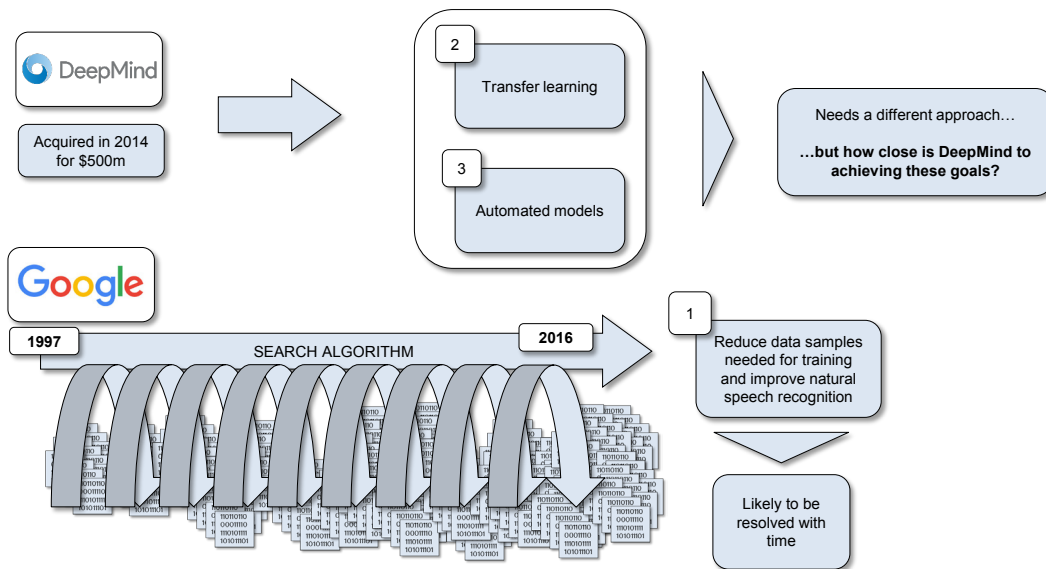
Source: Edison Investment Research

DeepMind

DeepMind is a UK AI company that Google acquired for $500m in 2014, which is a staggering amount of money for a company with no product, users or revenues. However, with the potential that DeepMind has demonstrated over the last nine months, it could end up generating far more value for Google than all of its other acquisitions. This is because DeepMind is engaged on solving the second and third goals of AI (Exhibit 17) which are by far the most difficult. If DeepMind can solve these problems and apply them to rest of Google, it would, in all likelihood have a substantial impact on the appeal of Google's ecosystem over those of its competitors. With over $2tn of market value being attributed to the ecosystems globally, success in this endeavour would make $500m a very low price to pay for DeepMind.

The problems that DeepMind is working on are transfer learning (Exhibit 5 and 17) and automated models (Exhibit 5 and 17). (Transfer learning is also referred to as general purpose AI in the AI community.) DeepMind has spent most of its time developing game-based AIs that can improve their own algorithms as they play. This represents a big step forward as algorithms in the past have relied on a technique called brute force forward search in order to play. This involves evaluating every possible move from a certain position then choosing one that is calculated to result in the best possible outcome. In chess, this works well as after two turns on the board there are only 400 possible moves that can be made. However, in the Chinese game of Go there are 130,000 (Exhibit 18). **This is why a brute force forward search does not work in Go as the AI would have to evaluate more moves than there are atoms in the universe.** Beating a human Go player has been a major AI target for some time as different techniques have to be used to build a machine that can play effectively.

Exhibit 18: DeepMind and AlphaGo
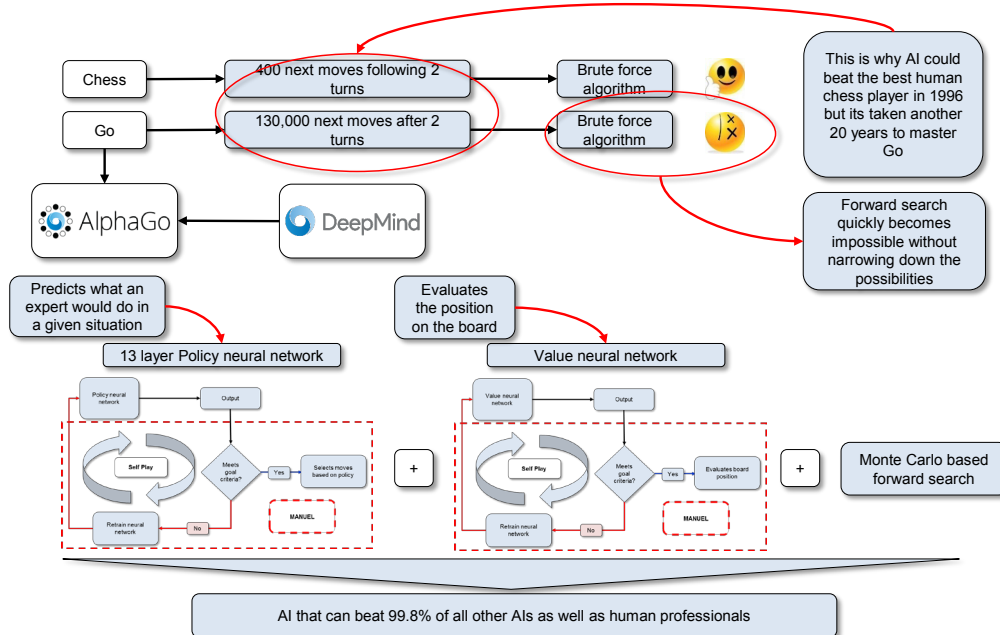
Source: Google, DeepMind, Nature, Edison Investment Research

In March 2016, a DeepMind-created AI called AlphaGo managed to convincingly beat one of the best Go players in the world. This was a feat that the AI community had been predicting would not happen for another 10 years. DeepMind could achieve this by using neural networks to substantially narrow down the number of move options that needed to be evaluated. AlphaGo consists of three pieces: a 13-layer policy neural network that predicts what an expert Go player would do in a certain situation; a value neural network that evaluates the position on the board; and Monte Carlo-based forward search.

This system was first trained by evaluating 100,000 games played by strong amateurs, then the AI was programmed to mimic human play. Once this was achieved the system was then left to play 30m games against older versions of itself with the goal being for the new version being able to beat the older version. The 30m games represents the period during which the two neural networks use reinforcement learning to improve the machine's performance to the requisite level.

The net result was an AI that was very good at evaluating the board's position in a way not dissimilar to how humans do it. At a high level, the system appears to work by using its knowledge and experience to work out which moves are worthy of assessment. This is what intuition would be called in a human player. This massively cuts down the number of options that need to be searched (Exhibit 19), making forward search a viable option for calculating what the best next move is. This is very like what Alan Turing and his team achieved with the cryptographic Bombe machine that was used to crack the "unbreakable" Enigma code during World War II. The difference is that in World War II it was the humans that narrowed down the search options and the Bombe that did the search but with AlphaGo, the machine does both.

Exhibit 19: DeepMind and AlphaGo do not yet approach AI summer
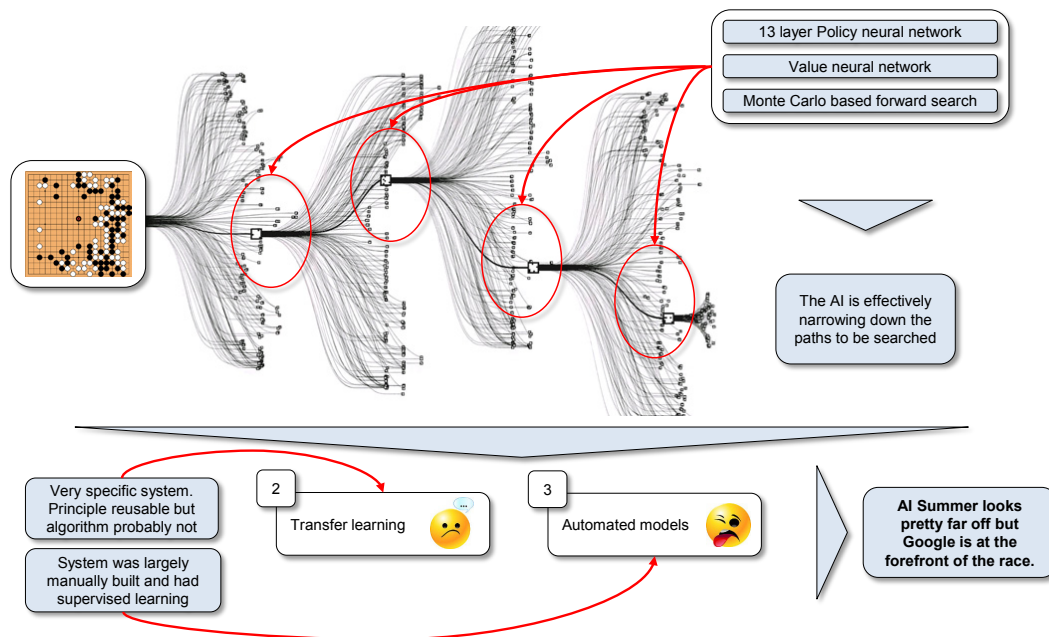
Source: Nature, Edison Investment Research

DeepMind's stated goal is to solve intelligence and, while AlphaGo is a step in that direction, Edison thinks that there remains a very long way to go before the goals of transfer learning and automated models can be considered solved. DeepMind claims that AlphaGo is a general-purpose AI, which means that the intelligence that it has created can be used in other applications without any further training. Edison thinks this really means the technique to create AlphaGo can be re-used but the AI itself would have to retrained to do something else. This is why Edison thinks there is still quite a long way to go before the learnings of one system are completely transferable to another.

Edison also finds that the ability of the machine to build its own models (or in DeepMind's case operate without models) is still quite limited. This is for two reasons. **One:** although AlphaGo gained a lot of its ability on its own, it still required humans to build the system for Go and there was a meaningful amount of supervised learning involved when it came to training. **Two:** DeepMind is still at a very early stage in terms of being able to master games on its own. Currently, the AI is capable of learning to play simple games like Breakout or Space Invaders, which require simple hand-eye co-ordination using nothing more than the data stream but little beyond that. This is new ground in terms of an AI being able to teach itself (ie, automated models) but the example of AlphaGo shows that to build something really complex still takes a huge amount of human input.

DeepMind has clearly shown it is a force to be reckoned with in AI but there is still a long way to go before these types of advances reach the point at which they can be incorporated into Google's ecosystem. Consequently, DeepMind remains mostly a research project for Google, but these are exactly the sorts of advances that could leapfrog Google's Digital Life services substantially ahead of its competitors. In the meantime, Google remains comfortably ahead in both long-term research and with the products that it has in the market today.

Google AI and the ecosystem

When it comes to AI that is available to ecosystem users today, Google remains the global leader. This is mostly due to Google's 20 years of experience with indexing and searching the internet enabling it to provide the most relevant responses to inquiries. Furthermore, this long experience has also enabled Google to obtain an ability to predict the inquiry. This is particularly useful as it enables Google to find the right information more quickly and with greater relevance.

As the digital ecosystem has evolved, Google has built upon its search offering to create a series of highly integrated services that it offers for free in return for the use of the data that the services generate. In this regard, it has been extremely successful as Edison forecasts that it has generated over $30bn in advertising revenues from mobile devices during the course of 2016.

However, not all of Google's endeavours have been successful and its attempts to address social networking with Google + and its multiplayer gaming offering have resulted in very little traction. Consequently, Google + has been migrated to become a media consumption offering and its gaming offering continues to languish with little traction and little in the way of investment. The net result is that while Google is doing extremely well when it comes to monetisation, it is only monetising 40% of the Digital Life pie (Exhibits 20 and 13), meaning that it is leaving a lot of opportunity on the table.

Google had originally intended to address this by increasing its offering of Digital Life services, but beyond its core competencies of Search, Mail, Media Consumption, Mapping and Browsing, it has failed to generate traction despite huge amounts of money being invested. Consequently, **Edison sees Google moving from trying to generate traffic with its own Digital Life services to working out how to collect data from services that it does not own**. This began with a service called Now on Tap that has now been rolled up into Google Assistant, which is Google's version of Siri, Cortana, Facebook M and so on.

Exhibit 20: Google's position in Digital Life, Q316, %
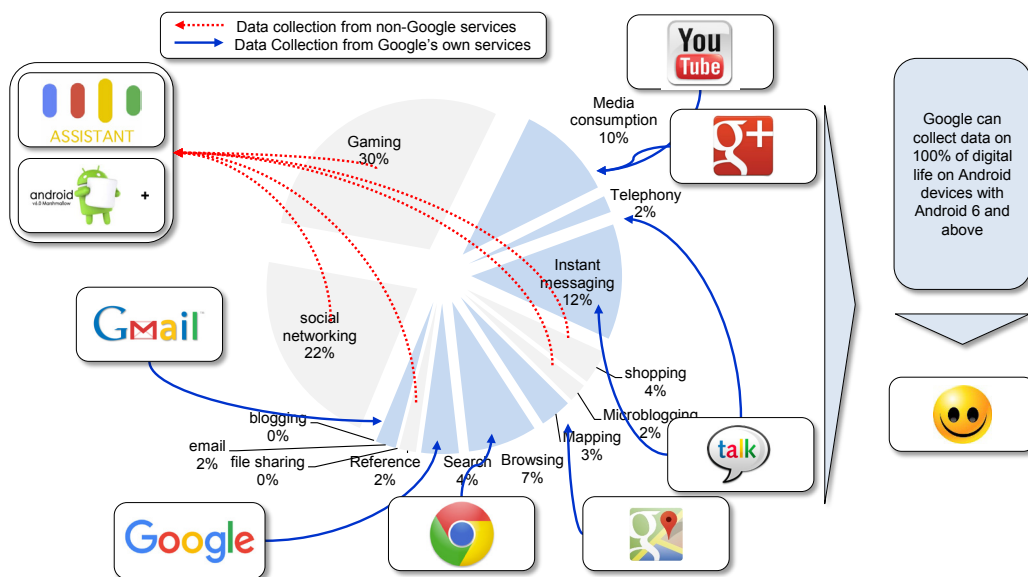
Source: Edison Investment Research, Nielsen, Google, Pewinternet.org, CommScore, NetMarketShare

This strategy originally took shape with the launch of Now on Tap, which is context-based search from any service on an Android device. For example, if the user is playing a historical strategy game from the Napoleonic wars, Now on Tap is able to provide the right answer to the simple question "who were the commanders?" Edison has long viewed this strategy as a stroke of genius, because while it provides the user with a useful service, **it also allows Google to collect data on Digital Life services that it does not own.** This means that Google will have insights and an understanding of its users that extends beyond the usage that is generated by its own services.

Edison believes that the opportunity for monetisation is closely related to how well the ecosystem has covered the Digital Life pie. This has so far been quite accurate in predicting the financial performance for both Twitter and Facebook during 2016. The real upside in increasing one's coverage of the pie is that an ecosystem can achieve both better pricing for its inventory of users as well as an increase in volume of the inventory sold. This means that covering more of the Digital

Life pie provides a non-linear increase in the total revenue opportunity. This is what Edison refers to as the gated community concept, which is discussed in more detail in Mobile ecosystems – Gated communities (page 3). **Edison believes that this strategy will not allow Google to generate revenues as if it owned the services itself, but it will increase the total monetisation opportunity.** This is because there are two aspects to monetising the Digital Life pie.

First: The more of the services of one ecosystem that the user uses, the more that ecosystem will know about the user. Therefore, targeting will be more accurate and more relevant and hence carry higher ASPs. This data may also be used to significantly enhance the experience of the ecosystem for that user, making it more sticky. It is this piece that Google Assistant can deliver to Google from services that it does not own (Exhibit 20).

Exhibit 21: How Google Assistant can increase the revenue opportunity
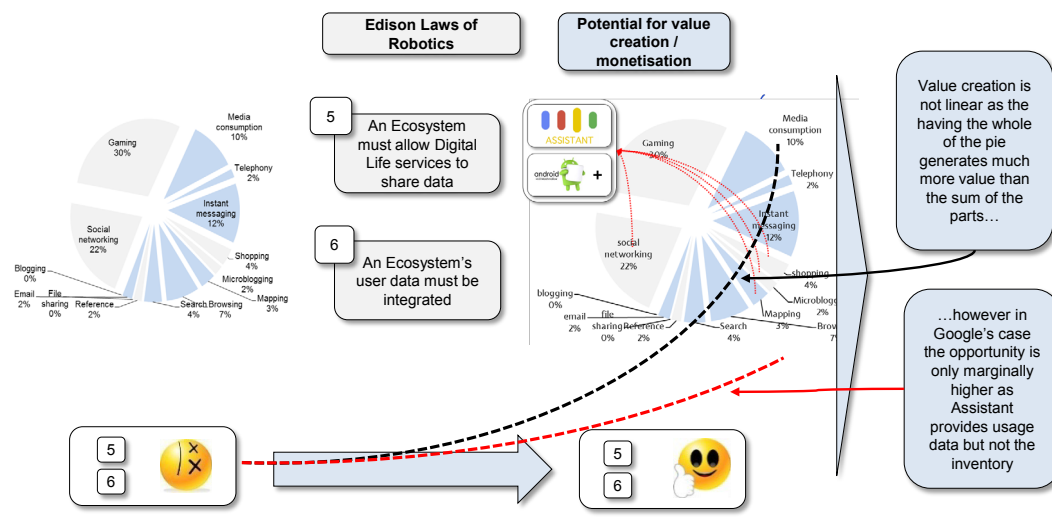
Source: Edison Investment Research

Second: The greater the number of Digital Life services that the user engages with, the more time the user will spend within that ecosystem. Hence there will be a greater opportunity to target the user with advertising and that user will have greater loyalty.

Combining, these two reasons makes it clear that the both ASPs and volumes will increase as coverage improves, giving a much greater uplift in overall revenues. **However, the incremental data provided by Google Assistant from Digital Life services that Google does not own will provide only one of the two possible uplifts in revenue.** Hence the opportunity will be substantially less (red line (Exhibit 21)) than if Google also owned the service (black line (Exhibit 21)), but nonetheless greater than if Google knew nothing about the other services.

There is one big weakness to this strategy that means that it is likely to be a long time before Google sees any benefit from this at all. That weakness is the fact that Google Assistant needs to have low level access to the device software that is running the services. This will not work on iOS devices because Apple will not provide Google with the necessary APIs for its assistant to work as designed. It will also not work on any device that does not run Android 6.0 (Marshmallow) or higher because it is only in Marshmallow that Google has included the necessary code in the Android Open Source Package (AOSP).
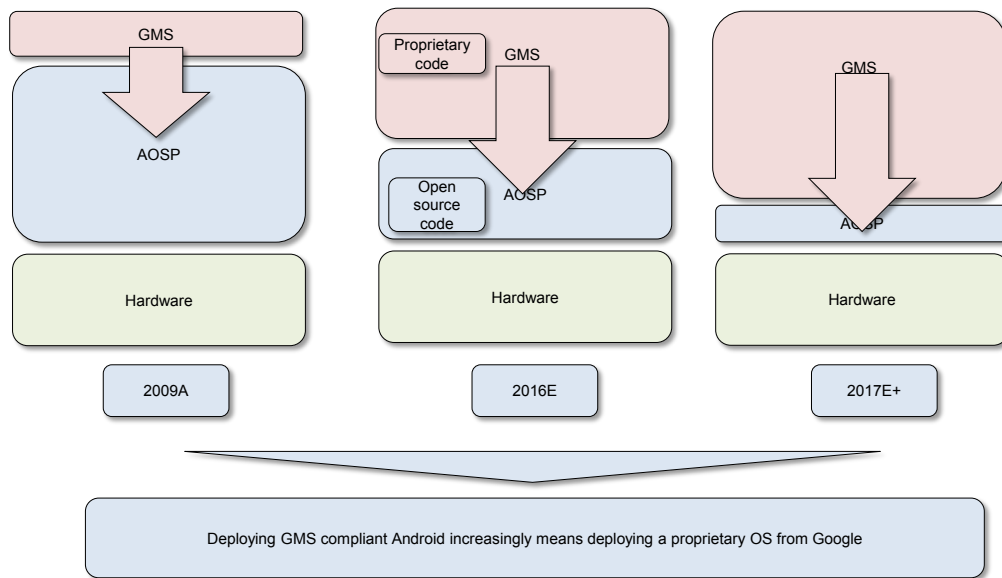
Exhibit 22: Android and iOS devices by OS version

Android devices by version — Latest OS version — iOS devices by version

7.0 Nougat 0%

5.0 Lollipop 34%

4.0+ ICS / Jelly Bean 15%

4.4 KitKat 25%

2.3 Gingerbread / Other 2%

6.0 Marshmallow 24%

0.3% carry the latest Google innovations compared to Apple at 75%.

Data collection on 100% of digital life possible with Android 6.0 and later. 24.3% of all GMS devices

iOS10 75%

Older 4%

iOS9 21%

Only 0.3% of Android devices are running the latest version

Apple's control of distribution has a profound effect on the user experience

Source: Edison Investment Research

Consequently, as of November 2016, out proprietary analysis indicates that from 100% of iOS devices and 75.7% of Google Android devices there will be no benefit from collecting data on services that Google does not own. On iOS this is understandable, but in Android this situation has occurred because Google remains incapable of distributing updates to its own software.

Google's inability to distribute its own software remains one of the most serious problems that the company faces. Edison thinks great example of how this problem is hurting Google's medium term outlook is the issue with Google Assistant. . This problem exists because of the open source nature of the Android software. This has meant that handset makers, device makers and mobile operators control the software update process rather than Google. Device makers are not incentivised to upgrade existing devices because it makes users less inclined to replace an old device with a new one. This problem is so acute that new versions of Android are effectively only installed on new devices, with the existing user base remaining largely untouched. Currently, 75% of iOS devices are running the latest version compared to just 0.3% of Google compliant Android devices (Exhibit 22). This is despite the updated software being made available at around the same time. It leaves Google's innovations such as the context based assistant service unavailable to the vast majority for a significant period of time.

This combined with the worsening software fragmentation within Google's Ecosystem (see Mobile ecosystems, Money talks, page 18) continues to underpin the case for Google to move almost all of the AOSP code into its services layer, thereby effectively making Google Android a proprietary operating system like iOS or Windows Phone (Exhibit 23). This would have the effect of killing two birds with one stone, alleviating both the fragmentation problem and the software distribution problems.

Exhibit 23: Development of GMS compliant Android

GMS

AOSP

Hardware

2009A

Proprietary code

GMS

Open source code

AOSP

Hardware

2016E

GMS

AOSP

Hardware

2017E+

Deploying GMS compliant Android increasingly means deploying a proprietary OS from Google

Source: Edison Investment Research

The advent of AI as a major differentiator for the ecosystem only increases the requirement for Google to make this move. Although the bulk of the processing and analysis carried out by Google's AI will occur in the cloud, there will be elements (such as data collection) that require certain pieces of code or APIs to be present on the device. Consequently, it remains as important as ever for Google to move its ecosystem as much as it can onto proprietary code so that it can control the increasingly complex devices that distribute its services to users.

Baidu

The king of Chinese AI

Although it is not nearly as well-known as many of its peers, Baidu ranks highly when it comes to its position in artificial intelligence. This is not because Baidu employs smarter or more innovative people than Microsoft or Amazon, but merely because it has been using AI for much longer than almost everybody else. Just like Google, Baidu's core business is search, where AI has been an essential piece of its business from day one.

Baidu was founded in 2000 as a search engine and since that time has grown in the Chinese market to be far and away the number one provider of search, with over 650 million active users of its search services every month. To obtain this position, Baidu has had to develop its web crawling and search algorithms to a very high degree. It is the learning that it has gained from developing the search business that has put it in a good position to develop other services that involve AI.

Exhibit 24: Baidu vs peers in global internet traffic generation, Q316
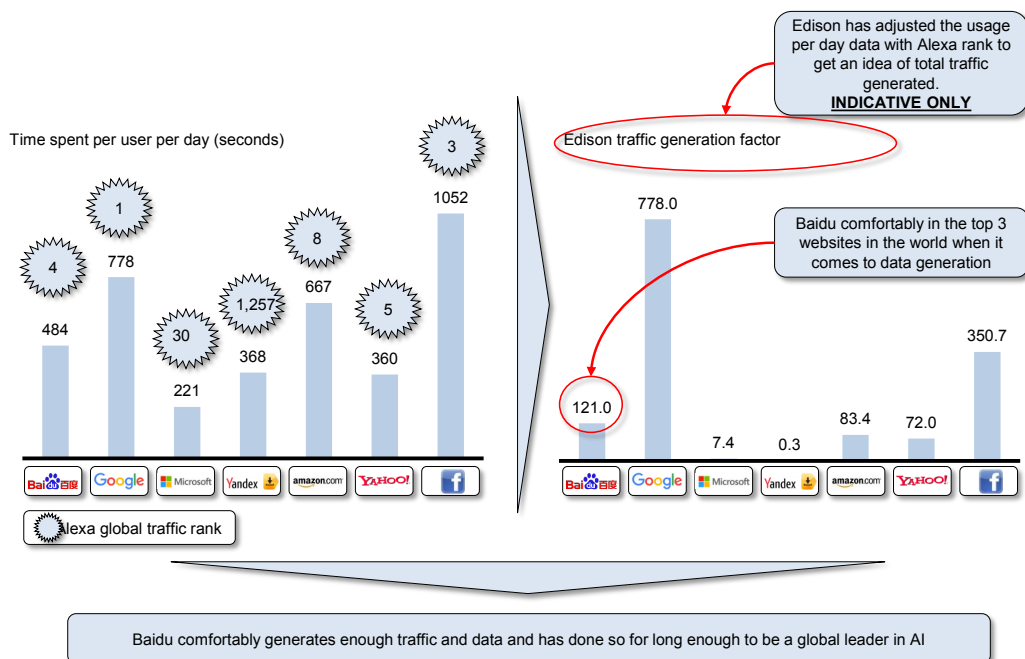
Source: Alexa.com, Edison Investment Research

Baidu undoubtedly has a strong position when it comes to internet traffic, as Alexa (page 40) gives Baidu a global rank of fourth (Exhibit 24, LHS) (China rank number one), which compares very favourably against Alibaba's Taobao at number 12 and Tmall at number 24. Furthermore, Edison thinks that Baidu's global traffic volume is comfortably in the top three. Edison has adjusted the top site's traffic per user by their overall Alexa rank to get a very rough idea of the total amount of traffic each website generates. This very simplistic analysis (Exhibit 24 RHS) puts Baidu in the top three globally in terms of total traffic generation, giving it a big advantage in terms of having a constant stream of data with which to train its AIs. Edison has already noted the importance of this to all the ecosystems.

With the wealth of data it has been generating for a sustained period of time, Baidu has trained effective search algorithms but is now looking to expand those learnings into the other areas of Digital Life. Baidu has already launched its own personal digital assistant Duer, AI-powered bots for doctors, face recognition software as well as self-driving cars.

Exhibit 25: Baidu's position in Digital Life, Q316
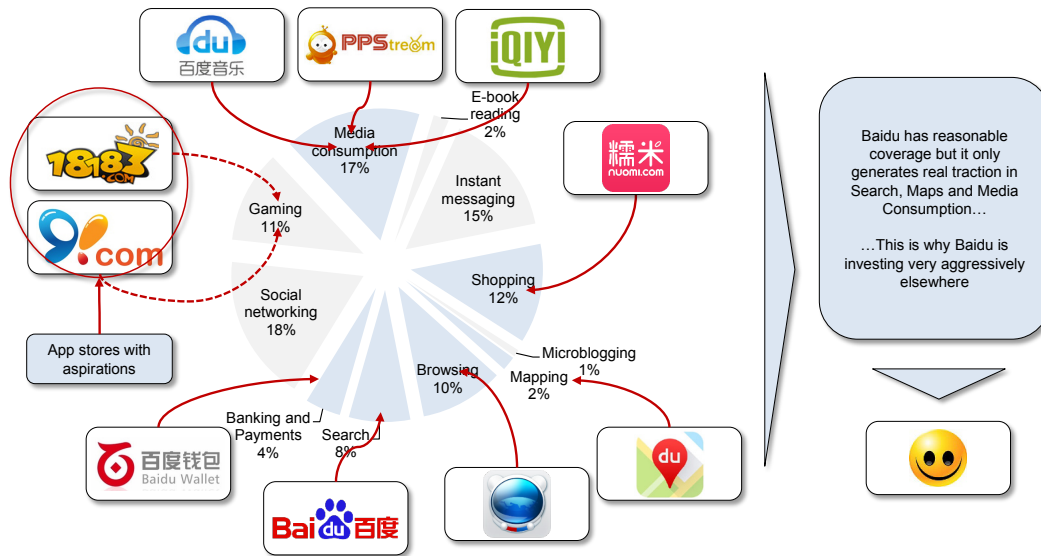
Source: Edison Investment Research, e-marketer, QuestMobile, WBR Research, DataEye, China Internet Watch, Flurry, iResearch

On top of these programs, Baidu also aims to use its AI to improve the competitiveness of its Digital Life services where they are competing against Alibaba or Tencent. Top of this list is Nuomi, which is Baidu's e-commerce offering in which it is investing to compete against Alibaba. Alibaba is hugely dominant in all areas of e-commerce in China (see Radio Free Mobile's China ecosystems, BATmen, page 34) and so to have a chance, Baidu has to offer merchants and users something different.

Baidu aims to differentiate with its other services (Nuomi.com and iQiyi) by using the data that it collects from search and maps to gain a deeper understanding of what its users do and do not like and what they are most likely to find interesting or useful. This is effected with a combination of both understanding user data as profiles (like Google) (Laws 5 and 6 (Exhibit 15b)) and then running that data through its AIs to arrive at a deeper understanding of its users. The net result for Nuomi's merchants is that users that go to the site are more likely to buy a product as the receiving merchant has a much better idea of what the user likes or what they are looking for.

Edison has long believed this is a major reason why Baidu is able to earn a much higher monetisation rate from Nuomi (Exhibit 26) than Alibaba does from its sites despite being a much smaller and lesser known destination.

This is the edge that Baidu has over its Chinese rivals, which could also be extended overseas with time. Despite this possibility, Edison does not see Baidu making a play outside of the Chinese market for some time to come as it is fully engaged on the very heavy investments it is making at home. This combined with its recent run-ins with the Chinese regulator over low-quality advertisements are likely to keep it focused on the Chinese market for now.

Exhibit 26: Baidu's monetisation of its ecosystem beyond search
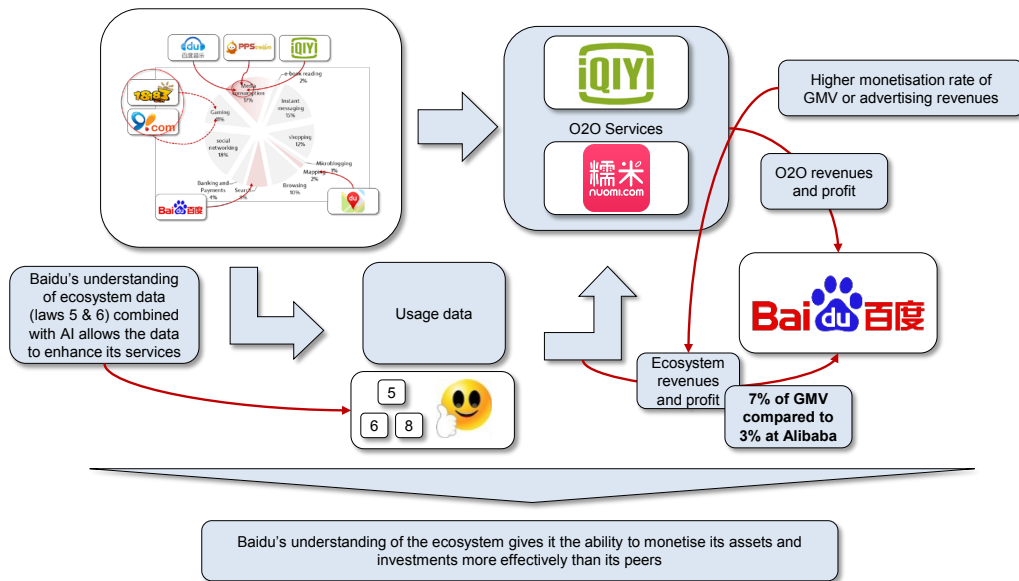
Source: Edison Investment Research, Baidu

Apple

Voluntarily hobbled

Apple owns the strongest ecosystem available today, but Edison thinks that its business model is not well suited to AI being used extensively across its products. **Furthermore, Apple is a latecomer to the AI race and the performance of its digital assistant, Siri, is way below that of Google's and barely on a par with Cortana (Microsoft).** This strongly implies that when it comes to competing against other ecosystems with its Digital Life services, Apple is already at a disadvantage. However, Edison's research has long indicated that Digital Life services are no longer where Apple aims to differentiate in the long term, which could explain why Apple has been late to this trend and why it often voices the opinion that there is more to competition than AI. Edison thinks that even where it sees Apple attempting to compete (HomeKit, HealthKit and Apple Pay), it has now realised that it will need AI and has been scrambling to assemble competencies in this area.

Apple is not the most visible participant in the AI community, although it has recently decided to engage much more actively with the community outside of its walls. Despite being one of the first to launch a digital assistant (Siri in 2011), its offering is very far from being the best. Even the major reworking that Siri had in 2014 has not put it within spitting distance of its rivals. Apple does not have a dedicated AI division nor has it published research implying that Apple is applying artificial intelligence in a patchwork fashion to the areas that need it.

Exhibit 27: Apple's ability to train Digital Life related AIs
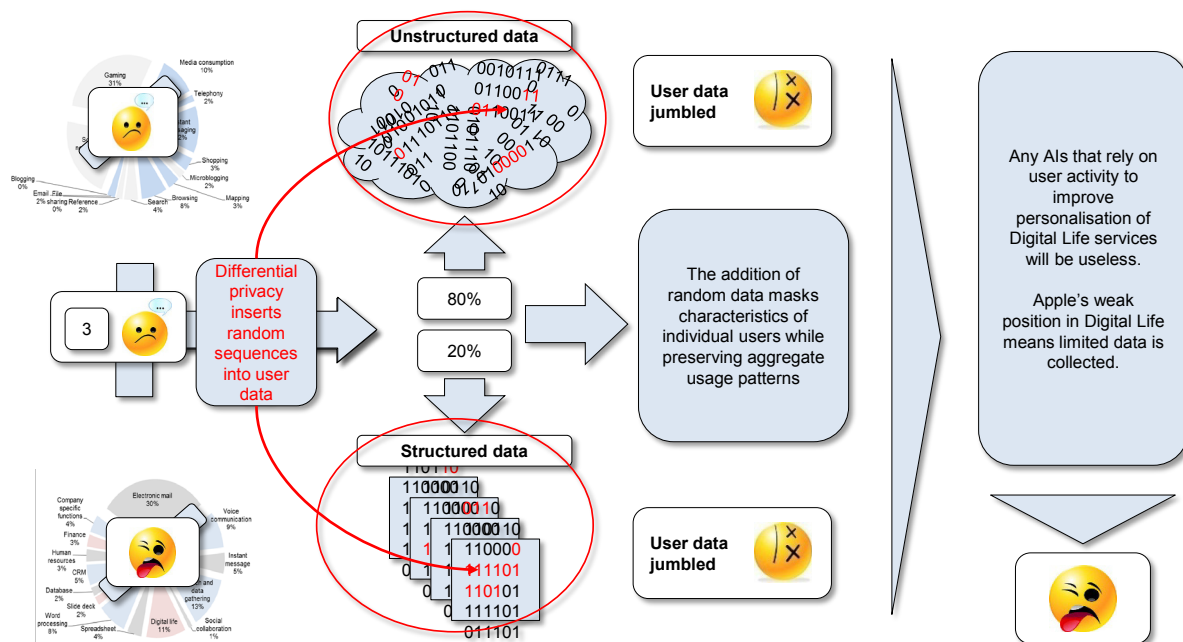
Source: Edison Investment Research, Apple

There is AI to be found in Apple's products such as the facial recognition of the camera app or the way the map app knows where one's car is parked without one telling the app one was driving. It also helps Apple News select stories that might be of interest as well as helping Apple Watch in deciding if you are exercising or just moving around. AI is commonplace throughout Apple's products, but it is isolated and it is piecemeal. It is also not really the kind of AI that learns as it goes along and Edison suspects that this is because of the data policies that Apple has set for itself.

Apple prides itself on being the ecosystem of privacy and has implemented a system that it calls differential privacy to safeguard and protect the safety and security of iOS users. **Apple is able to do this because its users have already paid for the ecosystem through the purchase of the device at a high price compared to what a user would pay for the same hardware specification on Android**. Differential privacy (Exhibit 27) is a statistical method of adding randomized data to mask the characteristics of individual users without changing the result produced when all the data is aggregated. In practice this means that Apple has no idea what individual users do but has an in-depth insight to the trends among its users.

Edison thinks that this is great for privacy but it is very bad for training AIs aimed at improving the quality of the iOS ecosystem for individual users. An AI designed to recognize patterns in a user's behaviour and then make suggestions to improve the quality of the experience for that user will always draw the wrong conclusions because the data that it is being fed has been scrambled.

This leaves Apple in a tricky position, as although it generates great volumes of data, the quality of data needed to train AIs to evolve the functionality of its ecosystem has been voluntarily hobbled. This means that in the long run Google and Baidu could develop services that are deeper and richer than Apple's own services. Fortunately, both Google and Baidu are likely to ensure that these services are also available on iOS, but there is some commoditization risk here for Apple. For example, should Google Assistant become a must have service, then some users may be tempted to try an Android device as Google's control of the platform is certain to ensure that it works better with better functionality on Android than it does on iOS. The default assistant on iOS is Siri, which is inferior and could very well continue losing ground to its rivals.

Exhibit 28: Apple's position in Digital Life, Q316
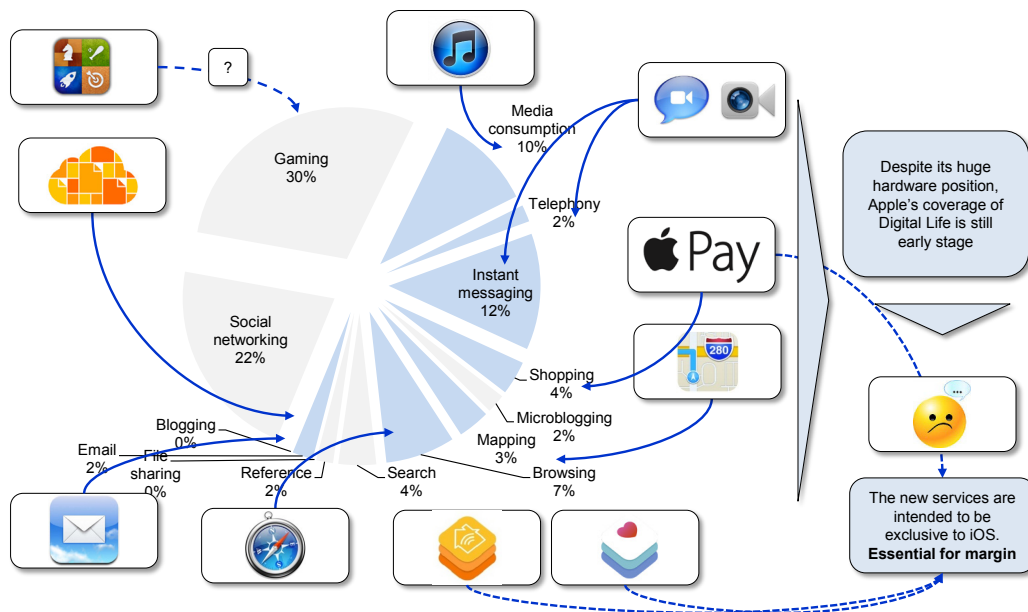
Source: Edison Investment Research, e-marketer, QuestMobile, WBR Research. DataEye, China Internet Watch, Flurry, iResearch

Apple appears to be aware of these shortcomings as it has taken some steps to mitigate the impact of its low data volume from not having a search engine or a strong position in Digital Life as well as differential privacy. These include a cache of user activity that is stored on the device that is personalised to the user. This includes app usage, individual training for speech recognition as well as neural networks for image recognition and so on. Effectively what Apple has done is to create a mini-brain that resides on the device (Exhibit 29). Differential privacy occurs as data is transmitted up to the server meaning that data stored in this mini-brain will be able to tailor the experience for

the user. Edison thinks that this will solve some of Apple's shortcomings in AI, but it will remain an inferior experience. Ecosystems run their AIs in the cloud as at full scale they are computationally very heavy and require massive amounts of data to become highly refined. These learnings are instantly available to the user as requests are transmitted to the server where the problem is crunched. What Apple has done is create a mini-server on the phone that will only be updated when iOS updates. Furthermore, AIs there will be constrained by the computational limitations of the device and will only have access to the data created by the user (Exhibit 29).

Exhibit 29: How Apple deals with differential privacy
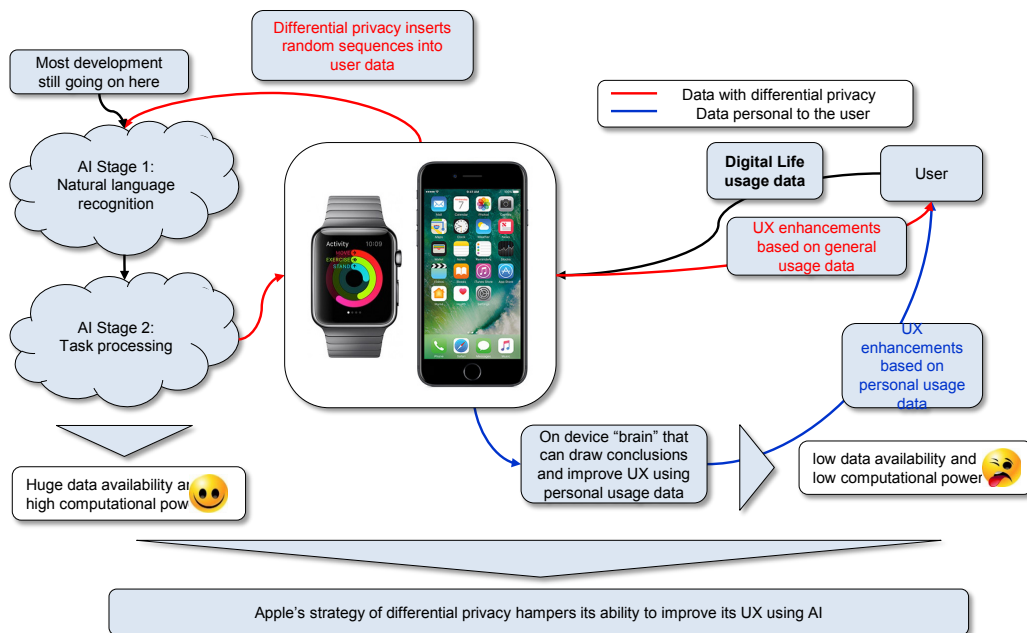
Source: Edison Investment Research, Apple

Edison thinks that running AIs on the device will mean that the improvements that Apple can make to the user experience as far as the individual user goes will be limited. Consequently, Edison sees Apple losing ground to its competitors Google, Microsoft, Amazon, Baidu and so on.

Fortunately, in the short term this is unlikely to be a problem as Apple has not been competing in Digital Life services for some time. Analysis of the Digital Life pie (Exhibit 28) shows that Apple's position has remained largely unchanged for four years and that Digital Life services is not where Apple competes. Instead Apple's main differentiator is that it distributes the apps and services of third parties in by far the easiest and most fun to use way. With Google continuing to struggle with its user experience, driven by the endemic fragmentation of Android and its inability to distribute its software, it is unlikely to catch Apple for some time to come (see Mobile ecosystems, Money talks, page 15). This gives Apple time to address its shortcomings in AI as well as develop its strategy for differentiation in the longer term. Edison continues to believe that Apple intends to differentiate in the long term by leveraging HomeKit, HealthKit and Apple Pay (see Mobile ecosystems – Gated communities, page 15 for more details). Edison believes that AI will also be a very important component of eHealth, Smart Home and mobile based payments, but here Apple has some time to work out exactly how it will use AI to improve these functions such that users will still be willing to pay a substantial premium for a device that gives them access to the iOS ecosystem.

Microsoft

Asset mismatch

Edison thinks that Microsoft has a mid-ranking position when it comes to AI. It appears to be currently on a par with Apple when it comes to performance of its digital assistant, Cortana, but its access to user data is far superior as it is not using differential privacy as a differentiator. This means that the AIs that drive its performance will be given the best chance of success, having access to both raw data and running in the cloud with maximum compute power. However, when it comes to traffic volume it ranks very far behind both Google and Baidu, and with Bing being launched in 2009, it has not been working on AI for very long.

Its developments are so recent that it has only just formed its AI research group of 5,000 computer scientists, led by Harry Shum, a 20-year Microsoft veteran, who until recently led Bing engineering. Microsoft aims to push its AI into Bing, automated bots, Cortana, automobiles as well as the enterprise.

It is here where Microsoft's strategy becomes a little unclear as the company's is in full retreat (Exhibit 30) when it comes to the consumer ecosystem, while its strategy in the enterprise ecosystem goes from strength to strength. Consequently, the future of offerings like Cortana, Bing, Minecraft and Xbox remain very uncertain as Edison thinks that these products will not live up to their full potential as part of Microsoft. **Consequently, Edison sees the potential for them to be sold, as these assets could be worth more to someone who has a strategy to leverage them to the max then they are to Microsoft**.

Exhibit 30: Decline of Microsoft's consumer ecosystem
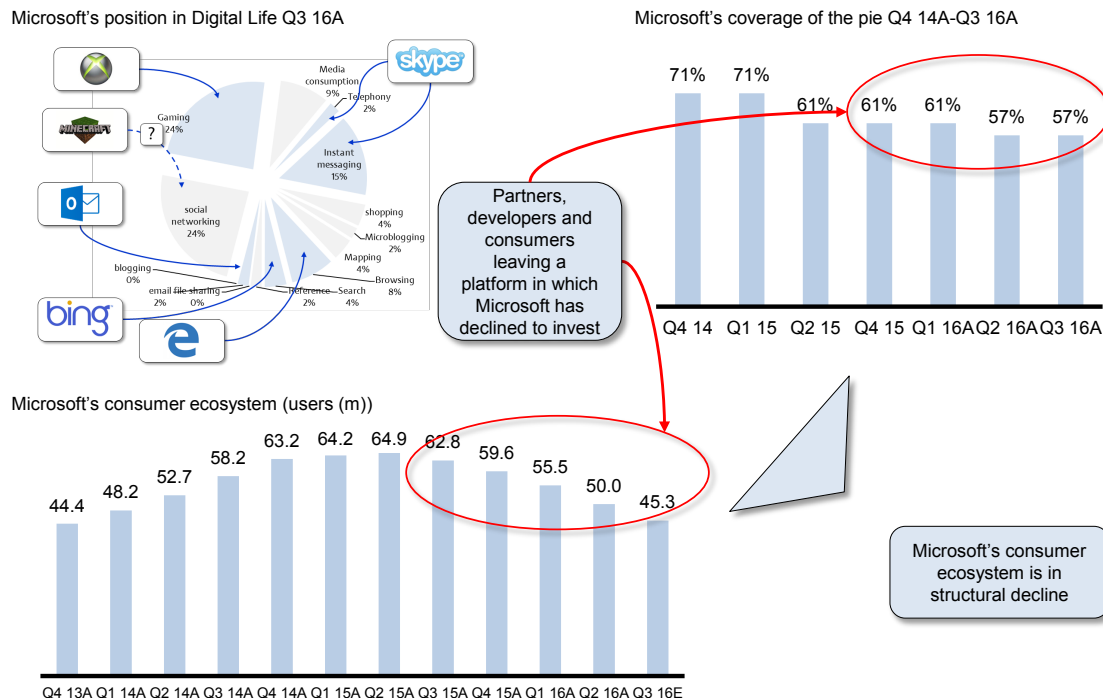
Source: Edison Investment Research, Microsoft

However, in the enterprise it is a completely different story, as Microsoft's coverage of the Digital Work has by far the strongest offering for the office environment (Exhibit 31). This is supported by a very strong offering of software infrastructure to support these services as well as the number two cloud offering globally. This is an area where Microsoft needs to invest heavily in AI as it will deliver

benefits in making Office, Skype for Business, Dynamics, LinkedIn and so on even more appealing to the enterprise user.

Exhibit 31: Microsoft in Digital Work, Q316
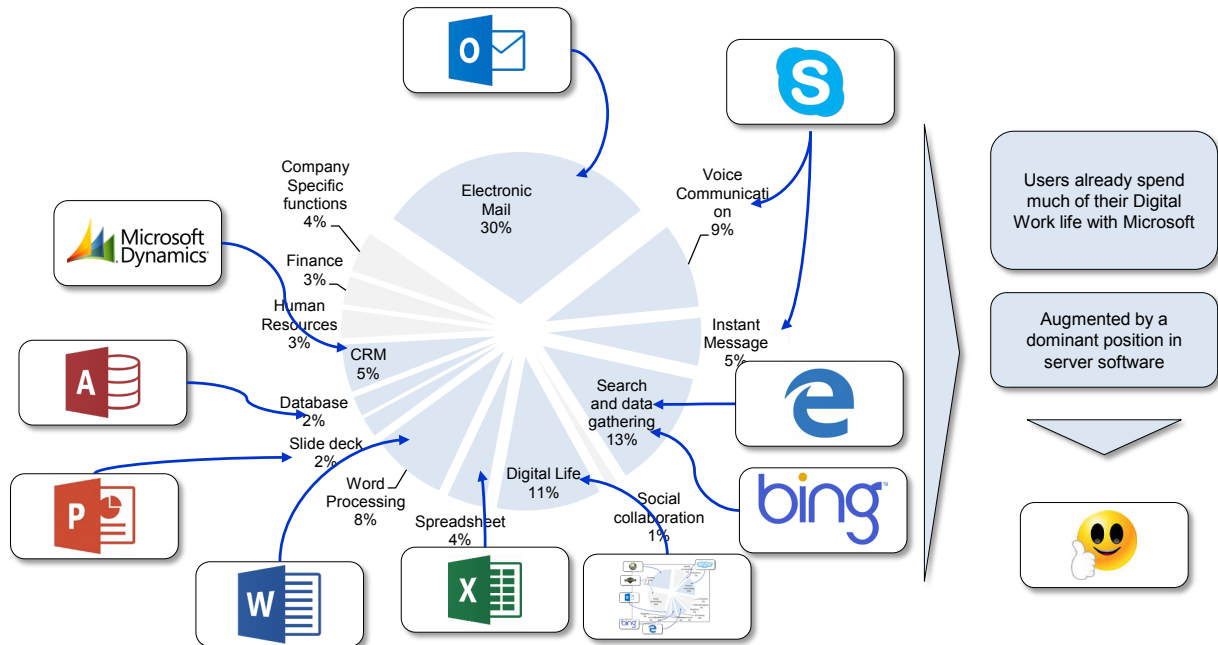
Source: McKinsey, Radicati, Workfront, Microsoft, Webtorials, Edison Investment Research

It is the apparent confusion in its consumer strategy that Edison thinks has pushed Microsoft to focus its investments on data recognition rather than really apply them directly to user facing applications. Edison has argued that the first stage of AI is to recognise and understand the vast amounts of data generated (Exhibit 3) and AIs that are generated for this function have the potential to be used in many different applications. For example, image recognition and natural language recognition are likely to become just as important in the enterprise as they will be in consumer, which is why it makes sense for Microsoft to invest in these areas. This is similar to the rationale that Edison sees driving Amazon (page 40. Hence, investments are likely to be based on their application in the enterprise, with the consumer ecosystem being icing on the cake, should these assets still be in Microsoft when the time comes to deploy them.

This approach also makes sense given the early stage of AI and the fact that all data will make little sense unless the machine understands it properly. Edison expects that this is will be the main focus of the 5,000-strong AI unit that Microsoft has put together, at least until it has made more progress with stage one (Exhibit 32). There is certainly urgency to get products into the hands of customers as quickly as possible, but Edison thinks that it is crucial to get the product right first before rushing it to market. AI-driven products require data to improve (Exhibit 3) and poor products are unlikely to generate much data as usage will quickly fall away as users realise that the product is inferior (Exhibit 10). Consequently, Edison expects Microsoft to take its time with its AI products, bringing them to market when it is good and ready.

Exhibit 32: Edison's view of Microsoft's AI investments
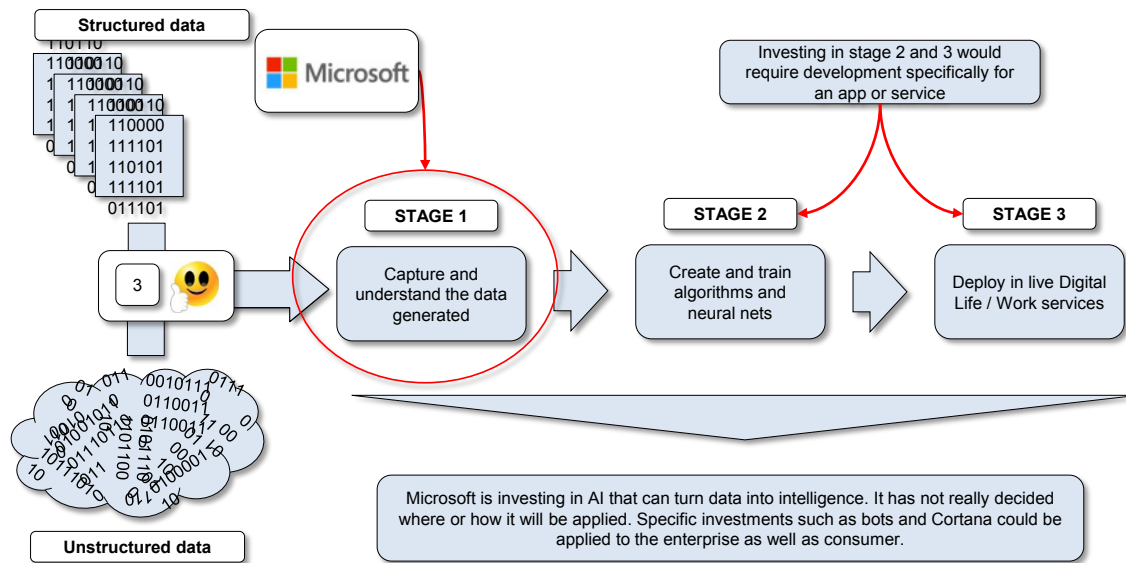
Source: Edison Investment Research, Microsoft

Amazon

Other applications

While Amazon was first to market with a device (Echo) that brings AI into the home, Edison does not consider it to be a leader. There are two reasons for this view. **First**, Amazon does not generate anything like the kind of traffic that the search engines do (Exhibit 24). Amazon has been working with the recommendation engine from its shopping website to train the Echo, but this is only one aspect of Digital Life. Despite being the biggest online retailer in the world, Amazon still ranks only eighth when it comes to traffic (Exhibit 24 LHS) and when this adjusted for its user base, it still ranks fourth (Exhibit 24 RHS). **Second**, Amazon is a relative newcomer to this field, having been working on the AI for Echo for just four years. This is one reason why the Echo is a relatively poor performer when compared to Google Assistant, Duer, Cortana or even Siri.

Exhibit 33: Amazon's position in Digital Life, Q316
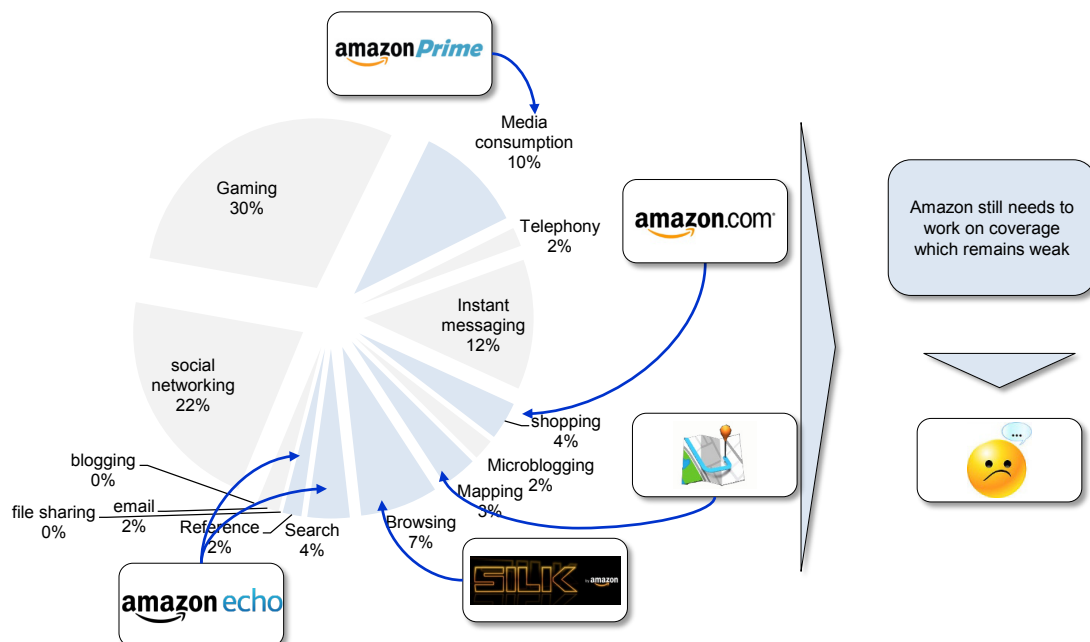
Source: Edison Investment Research, e-marketer, QuestMobile, WBR Research. DataEye, China Internet Watch, Flurry, iResearch

However, there is far more to Amazon than the digital consumer, as Amazon remains a very successful company despite its weak position in Digital Life (Exhibit 33). It is here where there are substantial applications for AI that could deliver far more benefit to Amazon than its consumer ecosystem is ever likely to. **Firstly**, Amazon has access to a lot of very specific data with regards to e-commerce, which Edison believes could be utilised far more effectively than it is today. For example, users are often presented with recommendations for products that they have already purchased, which are almost certain to result in a wasted advertisement. AI should be able to refine messages to suggest products to the user that they might like to buy based on historical patterns and previous searches, which if accurate enough would be beneficial for both the user and the merchant. **Secondly**, Amazon has major expenses when it comes to logistics as it differentiates its service via speed and accuracy of delivery as well as customer service. Where this cannot be automated, it results in substantial costs and is a big reason why Amazon has failed for many years to make a decent return on sales. We believe there is significant scope for AI to improve many aspects of Amazon's business from automation in warehouses, inventory management and robotics to deliveries. **Thirdly**, Amazon is the world leader in cloud computing, which is a business predominantly driven by scale and capacity utilisation. There is scope for Amazon to use AI to

accurately predict the ebbs and flows of its own capacity utilisation and thereby be able to support its client base with a lower spend on both capex and opex.

Amazon Prime and the consumer ecosystem is still very much a sideshow compared to these larger considerations and consequently Edison expects that the bulk of Amazon's AI efforts will be focused on the retail and cloud business rather than Echo itself. The fact that Amazon does not have anything like the data flow or the experience of Google in AI makes the Echo a sitting duck for Google Home assuming that Google can avoid the kind of mistakes that caused it so many problems with Nest.

Exhibit 34: Amazon's focus on AI
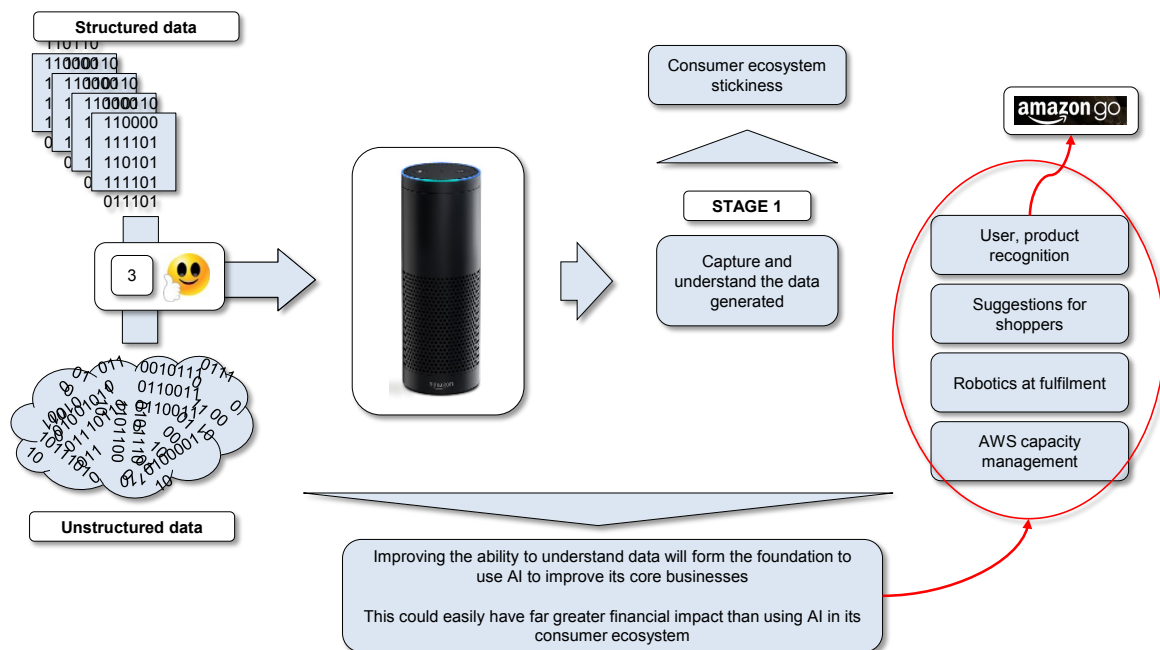
Source: Edison Investment Research, e-marketer

Amazon's current focus appears to be mostly limited to stage one: data capture and understanding. When the entirety of Amazon's business is considered, this begins to make sense as simply understanding its data better could result in significant benefits for Amazon (see above)

Thus, Edison sees Amazon focused upon developing AIs that relate to stage one, like natural speech recognition and replication as well as image recognition. However, to develop these, Amazon needs data and as it has no search engine; the Echo is a good product to collect data to improve its natural speech systems. Amazon is rumoured to be working on a version of the Echo that would also include a screen and presumably a camera. Amazon has been focused on voice to date but the inclusion of a screen would enable Amazon to be more proactive with its notifications as well as offer object recognition (for re-ordering) through the use of the camera. This would also have the added benefit of providing image and potentially video data needed to train the AI for image and video recognition.

Once trained, these AIs could be used to improve the stickiness of the consumer ecosystem, but more importantly there are applications in its newly launched retail store Amazon Go, robotics in its fulfilment centres as well as in Amazon Web Services (Exhibit 34). Amazon runs its businesses on wafer-thin margins, largely due to its investments in fulfilment, and the more this can be efficiently automated, the better its profitability can become. Given the size of this business compared to its consumer ecosystem aspirations, this could have a much larger effect on the bottom line than improving the stickiness of its consumer ecosystem.

Edison sees the Echo as a data collection device that is being used to improve its data recognition algorithms. Consequently, the profitability of Echo is much less of a concern, as the data that it collects has the possibility to meaningfully improve the profitability of Amazon's core businesses outside of the consumer ecosystem.

Facebook

Back of the pack

When it comes to the ecosystem, Edison analysis has long shown that Facebook is the new kid on the block, with the potential to emerge as the largest and most valuable ecosystem of them all (see Mobile ecosystems – Gated communities, page 18). However, as it stands today, Facebook is still pretty early on that journey, with a huge user base of 1.8 billion, but only a few Digital Life services, offering 36% coverage (Exhibit 35). Furthermore, the software infrastructure connecting all of these services is still at a very early stage, meaning that Facebook is still not really what Edison would consider to be an ecosystem in its own right.

Exhibit 35: Facebook's position in Digital Life
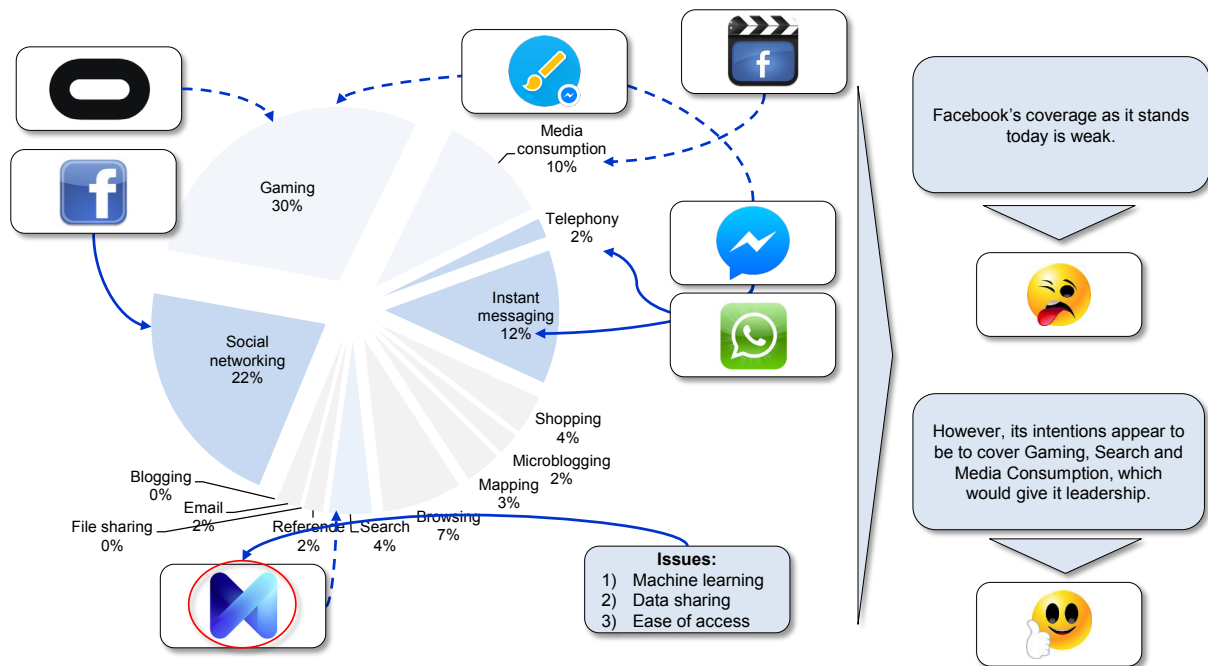
Source: Edison Investment Research, e-marketer, QuestMobile, WBR Research. DataEye, China Internet Watch, Flurry, iResearch

Edison thinks that it is by increasing its coverage of Digital Life and enticing users to spend much more of their time within its services that Facebook has the opportunity to increase its revenue opportunity from around $20bn today to $40bn (see Mobile ecosystems, Money talks, page 25). This is how Facebook is emerging as Google's fiercest competitor, as a large slice of that extra $20bn that we forecast in new revenues will not be coming from organic growth in the market but from taking share from Google.

However, it is when comparing Facebook to Google that Facebook's biggest weakness emerges. **When it comes to AI, Edison finds Facebook to be the least advanced of all the developed market ecosystems** (Exhibits 14 and 15(b)). Edison thinks that a major reason for this is that Facebook is very late to the AI game, which has been shown time and again to take a long time to master. The signs of this weakness are everywhere throughout the products that it has launched using AI and include:

- **Fake news**: Recent testing by the *Washington Post* found that the removal of humans from the news curation process led to fake news being displayed as trending. In the weeks following the move to automation, Facebook trended old news, fake news and conspiracy theories, and was also found to be slow when it came to picking up the real news. This is hugely problematic as enough people use Facebook for news that bias is becoming a big issue. **Facebook's response to this issue was depressingly labour intensive** with increased use of third-party fact checkers, verifying information with journalists and relying on users to report fake news all being cited as remedies. Edison takes this as a sign that Facebook's AI is very far from being market ready to trend news stories and remains far behind that of all the developed market ecosystems as well as Baidu.

- **Facebook M.** This is a digital assistant much like its peers except that it is based in the Messenger app and has a significant amount of human influence. Facebook M remains in beta testing but it is capable of completing tasks such as booking travel, ordering food and scheduling appointments. This sounds great but Edison's research indicates that when M is used to do any of things it is usually executed by a human using a telephone to order the food or book the tickets. Consequently, there appears to be very little intelligence in M at all, making it little more than a concierge service.

- **Bots.** Facebook has launched a series of bots that mostly aim to connect business more closely with their customers. The idea here is that the bot deals with all the frequently asked questions and then a human is rolled in if the enquiry becomes more complex. Facebook's record in this area is not great, although the bots that are driven by intelligence (like Poncho, the weather bot) have meaningfully improved over the last few months. That being said, Edison thinks that most of the improvements are a reflection of more detailed programming of the most common questions than a real step forward in intelligence. For example, Fify, the fashion discovery bot, can show the user jeans but failed to respond when it was asked for shoes.

The net result is that without a human element, almost all of Facebook's services that depend on AI tend to fall over pretty quickly. Edison does not believe that this is because it is unable to attract the best talent or that it has done anything particularly wrong. The problem essentially is that Facebook has been working on this for the least amount of time and therefore has a huge amount of ground to make up.

On the plus side, Edison thinks that availability of data is unlikely to be hindrance as Facebook has 1.8 billion users who log in at least once per month and the site remains number three globally, as ranked by Alexa (Exhibit 24). This means that the key criteria for Facebook to catch up are time and execution. When it comes to execution, Edison sees Facebook as having an excellent track record. Following its IPO in 2012, Facebook had real problems with its monetisation as its traffic suddenly started shifting to mobile and it had no mechanism by which to monetise the traffic. This caused real problems triggering a souring of sentiment and a 35% fall in the share price during H2 2014. Against this backdrop, Facebook acted swiftly to implement a system to monetise its mobile traffic and within a year (Q3 2015), mobile was close to 50% of revenues. This was accompanied by a full recovery of the share price, which has been very strong ever since. Facebook's monetisation has been first rate, which gives Edison confidence that execution will not be a stumbling block when it comes to Facebook's efforts to become a viable player in AI.

Exhibit 36: Facebook against the 8 Laws of Robotics, Q316
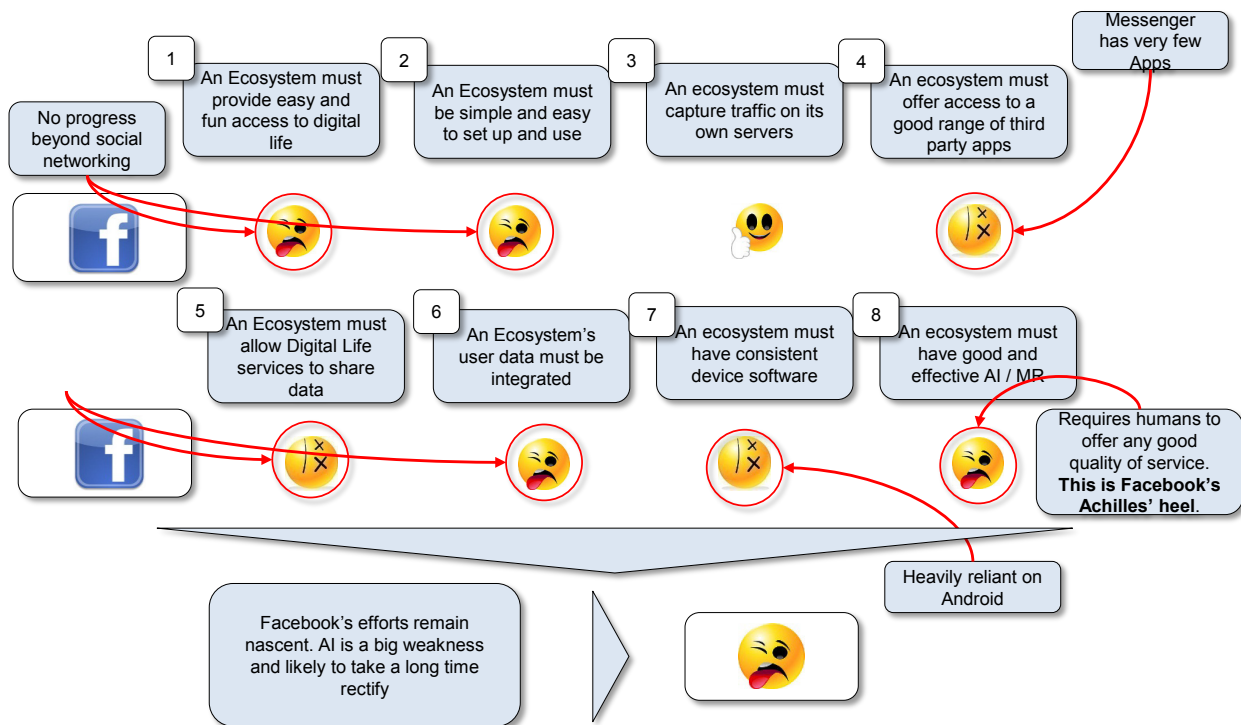
Source: Edison Investment Research

Facebook's weakness in AI combined with the nascent stage of its Digital Life offering (Exhibit 35) and the fact that it is still a series of apps rather than an ecosystem mean that there is still a lot of work to be done. Facebook also continues to score weakly on against the 8 Laws of Robotics as it has no distinct user experience that ties all of its services together in an easy and fun to use way. Edison thinks that all of this is under development, but until it hits the market, Facebook's revenue upside will continue to be capped and its growth slowed. The first evidence of this appeared in the Q316 results and Edison thinks that the short-term outlook remains difficult while its long-term services, software and AI remain immature.

Yandex

Although Edison does not yet count Yandex as an ecosystem in its own right, it is worthy of a section here as it is surprisingly strong when it comes to AI. Just like Baidu and Google, Yandex has been earning its living from search for around 20 years and it is comfortably the market leader in Russia. This means that it has a long history with AI, with the added benefit of having a good flow of Russian data with which to train its AIs.

However, the problem to date has been that Yandex has no platform of its own in mobile and instead has been dependent on Android and iOS. While iOS can work for Yandex in a similar fashion to how it works for Google, Android is another story. This is because Google and Yandex are fierce competitors and in the Russian market there is no firewall to protect local players like there is in China. This has left Yandex and Google fighting it out for control of the Russian market although Yandex has had some help from the Russian regulator.

Exhibit 37: Yandex's position in artificial intelligence
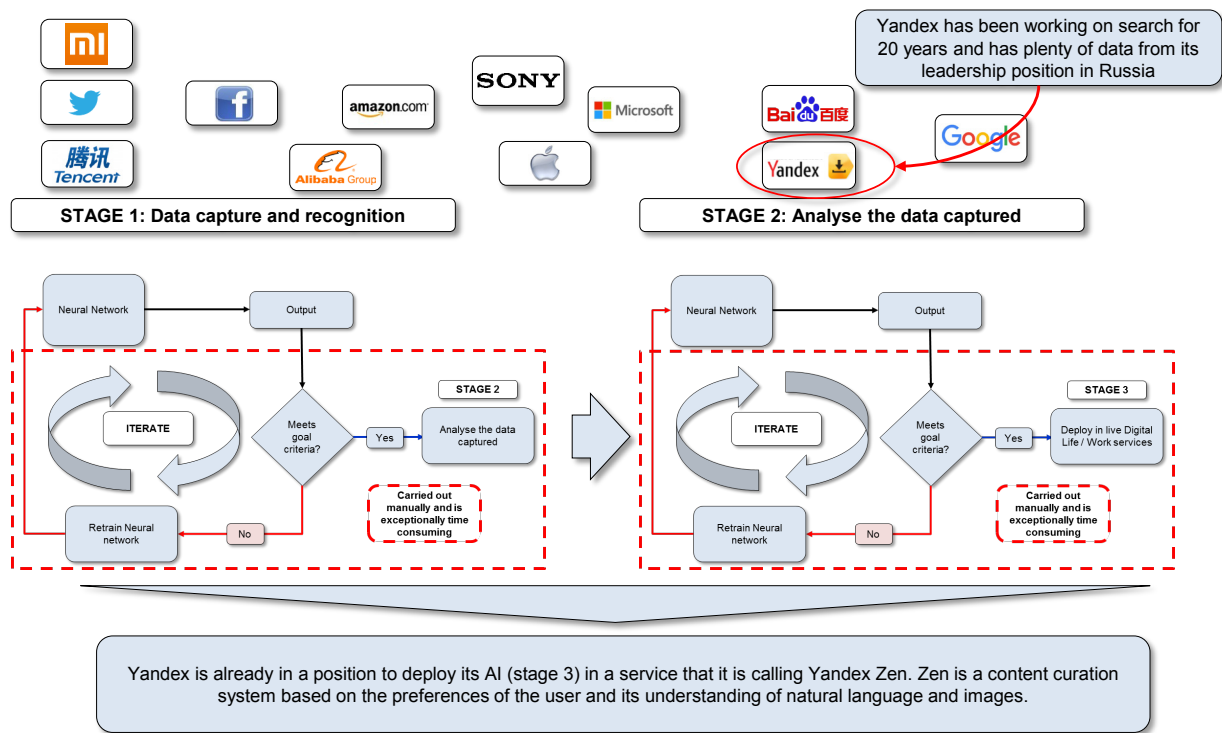
Source: Edison Investment Research

Part of the problem is that because Yandex services largely compete with Google's, almost all device manufacturers are precluded from making Yandex services their main focus. Instead they have to be added to devices where Google services are already present and set by default. This is why Yandex has become the partnership of choice from any handset maker or mobile operator trying to get out from under Google's skirt.

To improve the appeal of its services, Yandex is already at the stage of deploying its AI in different types of services to the end consumer. This puts it close to Google in terms of maturity as it has already reached stage three (Exhibits 2 and 37), but the scope of its AI-driven service, Zen, is still behind that of Google.

Zen uses its understanding of natural speech and image recognition to provide the user with a curated list of articles, news, videos and images that Zen thinks the user will like or be interested in,

based on their preferences and history. Zen is a little bit like Google Assistant in that it is built into both the browser and the app launcher but its functionality is still much more limited. Despite this, Yandex has managed to get a number of handset vendors to deploy it. Fly, MTS, Multilaser, Posh Mobile, Wileyfox, Lava and ZTE will all make devices that support Zen that will be available in Europe, Latin America and Africa.

Yandex is also deploying a complaint button for annoying advertisements that allows users to block annoying advertisements on their devices. The clever piece of this service is in the back end as this data is fed into the AI to work out which users like which products and then conclude how advertisers can more effectively target their campaigns with better hit rates. A higher hit rate means that Yandex will be able to charge more for its advertisement inventory and the advertiser will be able to run a more effective campaign.

The fact that Yandex is already at stage three (Exhibits 2 and 37) when it comes to developing its AI is a good indication that its development of AI is quite advanced, although it does remain quite focused. Compared to Google, Yandex's field of deployment is quite narrow although it has been working on autonomous piloting software for quite some time. Yandex represents a good option for those looking for the kind of freedom that Google denies them but it is certainly behind Google, with quite a narrow focus and limited to Russia and emerging markets. However, compared to Apple, Microsoft, Amazon, Alibaba and so on, Edison thinks that it is ahead.

Conclusion

With AI still in its infancy, there is plenty of scope for the landscape to change over the next five to 10 years. The search engines have the initial advantage and are doing everything they can to maintain that edge. However, with their livelihoods on the line, the others are also bent on closing the gap.

Most players are still grappling with understanding their data and have not yet begun to work out how they can then use that data to differentiate their consumer ecosystems. This puts Amazon, Microsoft and Alibaba in a good position, as these three have substantial businesses outside of the digital ecosystem that can benefit from the AIs that are generated just by understanding their data more effectively. This is where Edison sees both Apple and Facebook struggling. Apple appears to have voluntarily hobbled its ability to learn from its users through its use of differential privacy but as long as it remains the strongest ecosystem, driving differentiation from its third-party apps and services, this is not going to a problem. It is Facebook where Edison has the gravest concerns as the evidence points to Facebook having issues the minute it tries to automate anything. This is a problem as Facebook will need to offer customised services to its users to become the pre-eminent ecosystem. Automation is critical, as offering customised services to 1.8 billion users using humans would be cripplingly expensive.

The big ecosystems are all very well-funded and so both their in-house R&D and their M&A activity is likely to increase in 2017. AI is also likely to be the buzzword in many of the trade shows in the coming 12 months and for once, it will be more than just hype.

Exhibit 38(a): Laws of Robotics 1-4 for the bottom six ecosystems
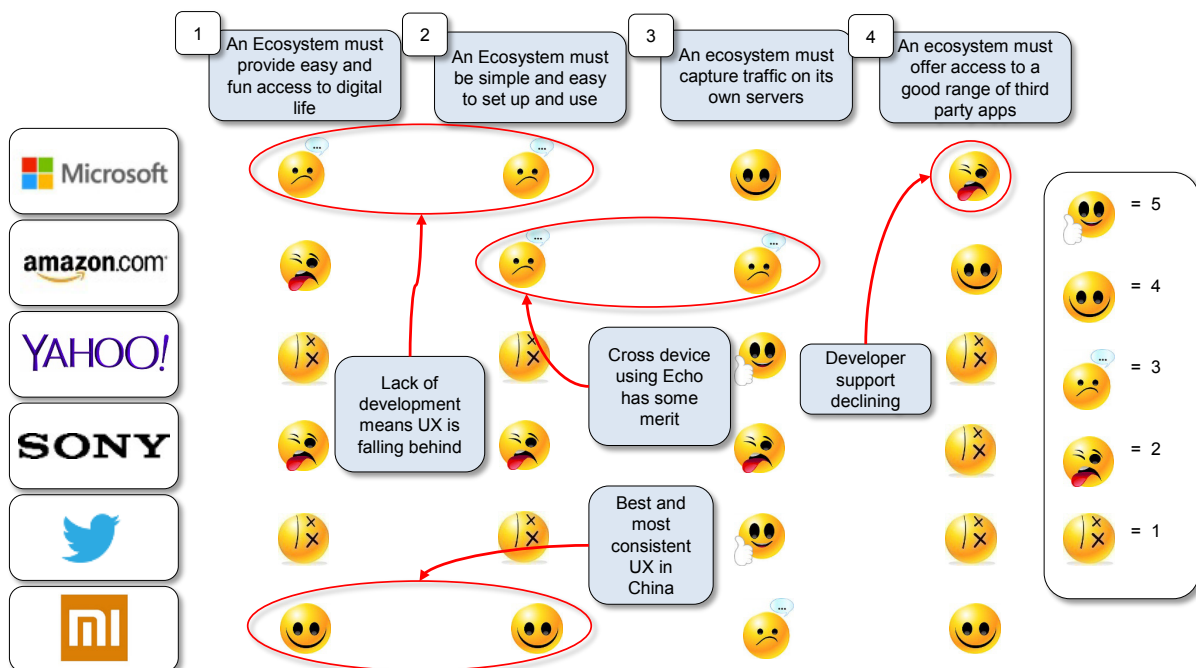
Source: Edison Investment Research

Exhibit 38(b): Laws of Robotics 5-8 for the bottom six ecosystems
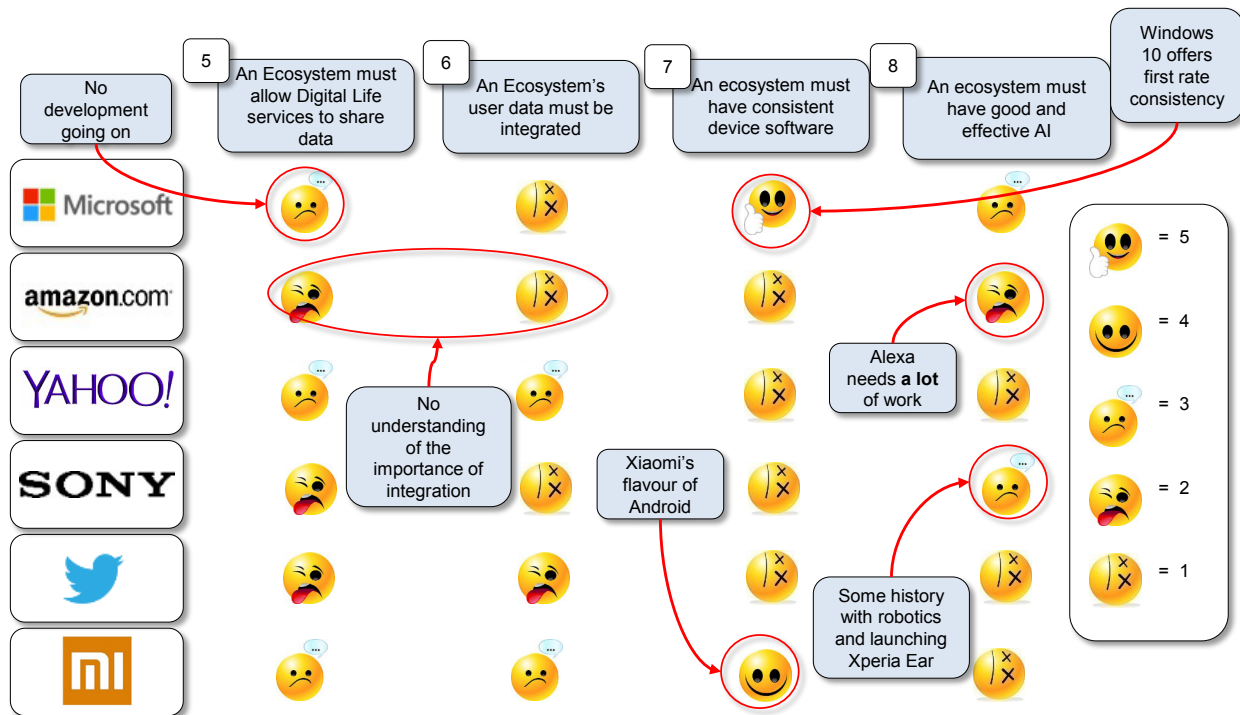
Source: Edison Investment Research

Ecosystem estimates

Exhibit 39: Mobile ecosystem user numbers and share

Ecosystem users (m)	2012	2013	2014	2015	2016e	2017e	2018e
Symbian	50.0	21.2	0.0	0.0	0.0	0.0	0.0
Tizen	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blackberry	0.4	0.4	0.0	0.0	0.0	0.0	0.0
iPhone OS	195.4	257.1	331.8	403.6	428.9	439.0	440.6
Windows	20.0	44.4	63.2	59.6	41.2	28.9	21.6
Facebook	625.0	945.0	1,189.0	1,440.0	1,644.0	1,744.0	1,804.0
Amazon	12.7	18.2	27.7	47.9	80.1	124.2	184.8
Firefox	0.0	1.2	1.9	2.3	2.5	2.7	2.8
Jolla	0.0	0.1	0.4	0.9	1.2	1.4	1.5
Android	614.5	1,030.0	1,517.4	1,965.3	2,275.8	2,517.7	2,730.6
o/w Google	179.4	360.1	614.3	878.8	1,017.4	1,126.1	1,221.9
o/w China	254.0	421.7	556.9	662.1	698.1	727.6	753.7
o/w Other	181.1	248.2	346.2	424.4	560.4	664.0	755.0
Yahoo!	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Samsung	10.4	117.4	21.2	26.5	29.2	30.6	32.1
Sony	35.0	53.0	63.4	61.7	48.4	40.4	35.7
Xiaomi	7.2	21.6	65.7	104.8	127.4	145.2	158.4
Total	925.6	1,523.4	1,997.1	2,516.8	2,823.5	3,056.6	3,260.3

Ecosystem share of users	2012	2013	2014	2015	2016e	2017e	2018e
Symbian	5.4%	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%
Tizen	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Blackberry	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
iPhone OS	21.1%	16.9%	16.6%	16.0%	15.2%	14.4%	13.5%
Windows	2.2%	2.9%	3.2%	2.4%	1.5%	0.9%	0.7%
Amazon	1.4%	1.2%	1.4%	1.9%	2.8%	4.0%	5.5%
Firefox	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Jolla	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Android	66.4%	67.6%	76.0%	78.1%	80.6%	82.4%	83.8%
o/w Google	19.4%	23.6%	30.8%	34.9%	36.0%	36.8%	37.5%
o/w China	27.4%	27.7%	27.9%	26.3%	24.7%	23.8%	23.1%
o/w Other	19.6%	16.3%	17.3%	16.9%	19.8%	21.7%	23.2%
Yahoo!	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Samsung	1.1%	7.7%	1.1%	1.1%	1.0%	1.0%	1.0%
Sony	3.8%	3.5%	3.2%	2.5%	1.7%	1.3%	1.1%
Xiaomi	0.8%	1.4%	3.3%	4.2%	4.5%	4.7%	4.9%
Total	100%	100%	100%	100%	100%	100%	100%

Source: Edison Investment Research, Counterpoint Research