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Perspectives on IoT

Analyzing Growth, Opportunities and Defining Selection Criteria

A Technical Paper
Prepared for SCTE/ISBE by

SANJAY DORAIRAJ
SR DIRECTOR, COMCAST INNOVATION LABS
COMCAST CORPORATION
1050 ENTERPRISE WAY, SUNNYVALE, CA 94089
Phone: 2159002349
Email: Sanjay_Dorairaj@cable.comcast.com

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Introduction

The Internet of Things (IoT) is the buzzword of the present time and everyone is trying to figure out what this means and the opportunities that it affords. While the stated goal of IoT, which is to get everyone and everything online and connected is simple enough to understand, the implications of this ubiquitous connectedness are quite profound. In understanding IoT, a fundamental problem is that most contemporary literature attempts to zoom in on a particular technology or a particular industry vertical without taking a step back and looking at the bigger picture. This paper attempts to shed a different perspective and view the evolution of IoT through the lens of Ray Kurzweil's Law of Accelerating Returns [1]. This provides perspective on the accelerating pace of IoT adoption and helps explain several models posited around its explosive growth. Next, we try to visualize the possibilities in an IoT world by looking at an extreme case of IoT where everyone and everything within the home are connected. This exercise helps us better visualize the exhaustive opportunity space and the true promise of IoT as opposed to narrow perspectives that are typical of most material on IoT today.

Visualizing the possibilities and the promise of IoT, while exciting, is also quite overwhelming. This is because the possibilities are quite frankly, endless. The challenge then is to sort through the possibilities and the associated technological and business challenges and identify opportunities that make sense for an MSO to pursue. This paper provides such a framework for pursuing opportunities with IoT. The framework that is proposed is focused on trying to build lasting value for the MSO by looking at the entire value chain for each opportunity and determining if it makes sense for the MSO to participate within that value chain. Finally, we walk through an example of identifying a candidate opportunity and then using the framework to determine if the opportunity is viable. This paper is focused on the home where MSOs have a majority of their presence, although, the concepts and ideas can be safely extended to other use cases involving IoT as well.

Content

1. The Law of Accelerating Returns

The Internet of Things (IoT) is the next logical step in mankind's endeavor to quench our insatiable desire to communicate with everyone and everything. The phenomenon that started numerous centuries back with the advent of the spoken word is now looking to pervade every aspect of our lives, as we embark on an ambitious journey to bring the gift of speech to not just everyone, but to everything. The implications of networking the world in this paradigm-changing manner are huge. Equally consequential is our ability to put these transformations into perspective and what better way to rationalize these epochal changes than by looking at it through the lens of Ray Kurzweil's "*law of accelerating returns"* [1].

1.1. Rationalizing the evolution of the Internet of Things

In his seminal book 'The Singularity is Near', Ray Kurzweil provides a very insightful way to model the pace of technological change. While progress in the evolution of technology was traditionally considered to be linear, Ray Kurzweil examined technological progress through the beginning of time and concluded that technological progress was in fact exponential. He termed this the "law of accelerating returns" and this law essentially posits that the exponential pace of technological progress is a result of the compounding effect on new technologies from the exhaustive set of existing technologies. Ray Kurzweil

also adds that the exponential growth is often subtle and unnoticeable till it reaches an inflection point and takes off to widespread adoption.

The pictures below show the evolution of various technologies through time. The first graph shows how when viewed linearly, there is a clear exponential growth in the evolution of these technologies. The second graph is a logarithmic plot that captures the same exponential growth of these technologies.

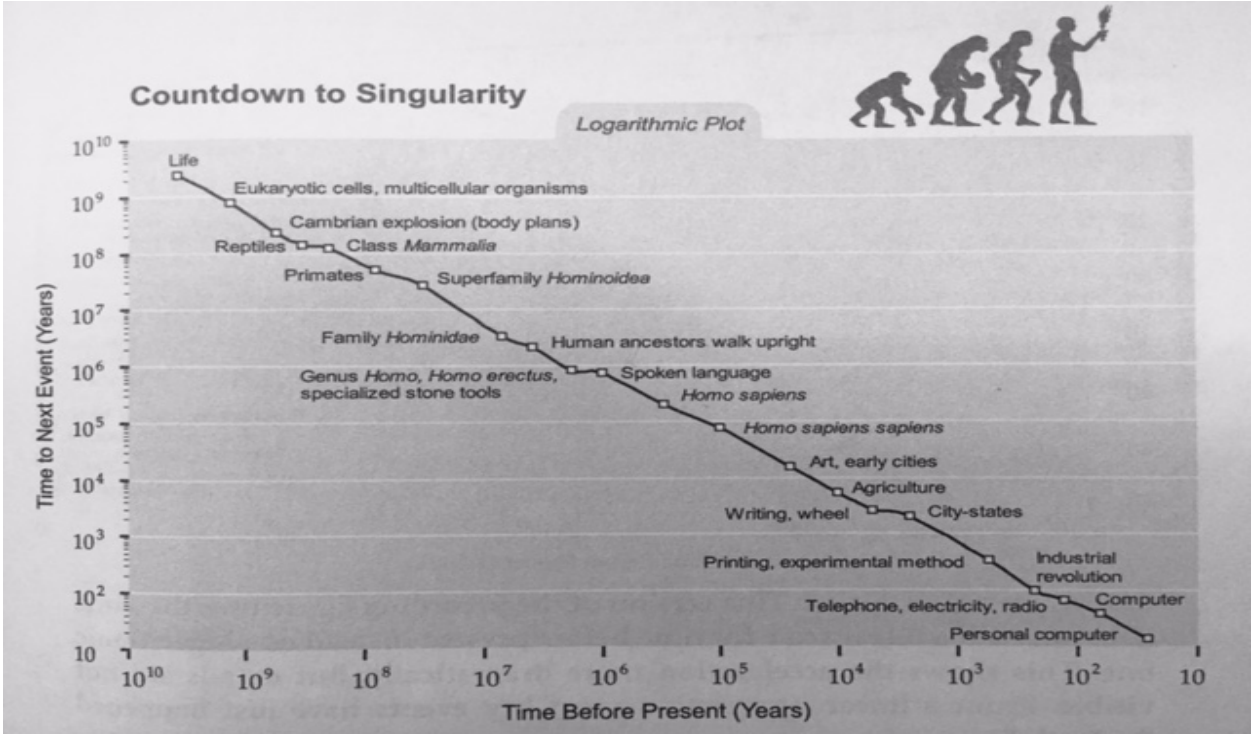

Figure 1 – Exponential Growth of Technology [1]

When viewed in similar light, the Internet of Things, as the next logical evolution of the Internet, is also set for exponential growth, leveraging the plethora of existing technologies that have gone before it including the ubiquitous Internet.

We are already beginning to see this explosive growth in various aspects of our lives beginning with industry applications and steadily entering our homes and workplaces. The confluence of low prices, improvements in sensor technology, the miniaturization of connectivity hardware and, smaller and longer lasting batteries are together helping advance the adoption of IoT. In several verticals, IoT is sought as an active agent to help drive down costs and help boost revenues. For example, in the embattled healthcare sector, where rising costs are threatening to bankrupt US Medicare and Medicaid reserves, IoT as the primary vehicle for in-home preventative care, is seen as a beacon of hope. The Center for Medicaid and Medicare Services (CMS) is now actively looking at in-home telemedicine as a meaningful way to keep patients in the home and avoid costly hospital admission costs [2]. Opportunities such as this when combined with other similar opportunities together help fuel the next stage in the evolution of communication technologies, which is the IoT.

1.2. An insatiable need to communicate

Our insatiable desire to communicate has helped drive explosive growth in various forms of communication technologies through the ages. Starting with the evolution of the spoken word to written communication, to wired and wireless forms of communication and the Internet, we have always been most productive and the most comfortable when we communicate with each other. Consequently, we have attempted to instrument communication into every aspect and every thing in our lives. The Internet of Things (IoT) is merely a logical extension of that desire to get everyone and everything in the world to be able to talk with each another.

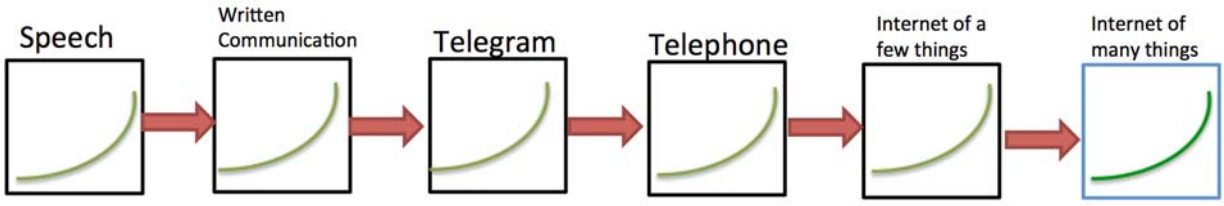

Figure 2 – Exponential growth in communication technologies

A look at the evolution of in the US telephone industry reveals that the phone industry took a little over a century years for the telephone to reach significant levels of usage in the United States since its inception in 1890[2] till the present day. In sharp contrast, the next significant milestone in communication technology, the cell phone, took a mere 30 years from inception in 1985 to worldwide adoption in 2005 [1]. Other technologies, like radio, computing and the Internet have likewise evolved at exponential rates of growth relative to previous set of technologies.

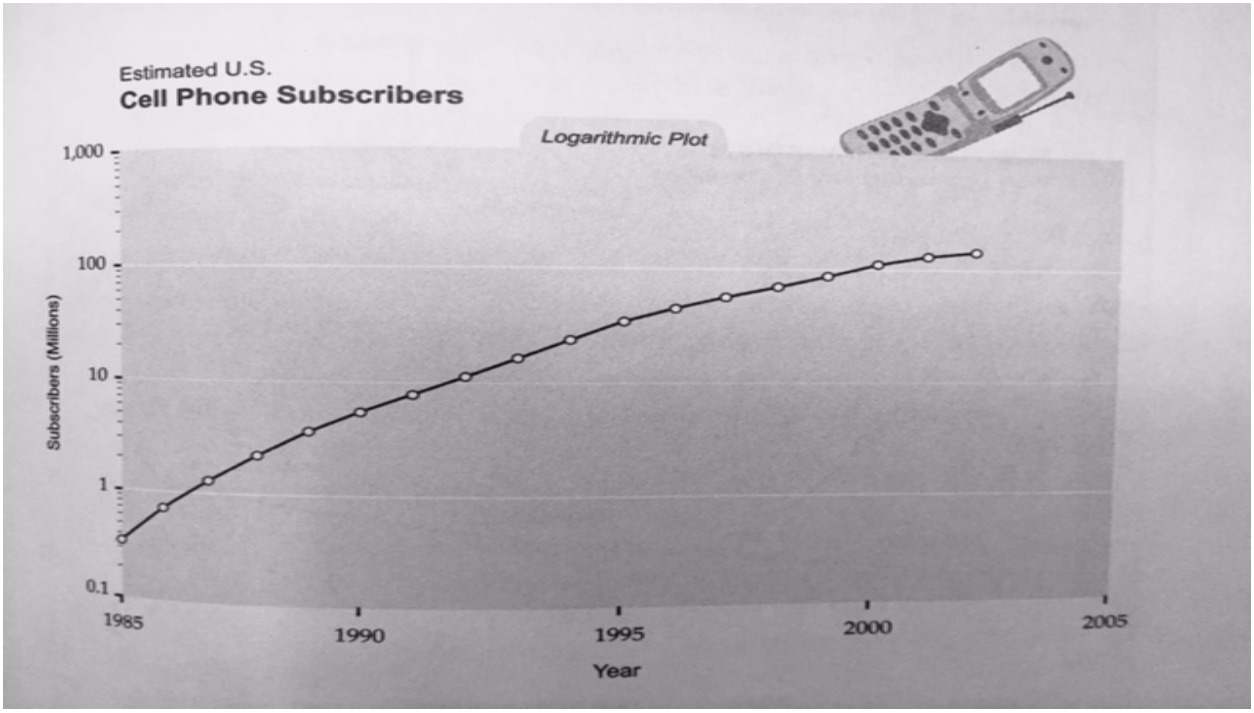

Figure 3 – Exponential Growth in Cell Phone adoption [1]

1.3. Natural selection within the Internet of Things

The accelerating pace of IoT heralds numerous opportunities for those who are looking to enter this space. We are still in the early days of trying to understand the implications of IoT and continuously seeking frameworks that can help us build and deploy IoT solutions. First movers will be able to build beachheads in this space that will hopefully help them establish their reputation and build barriers to entry for others. As with any other technology, there will be numerous attempts to build solutions based on IoT. There will also be numerous failures and some successes. Natural selection will help establish a positive feedback loop that will allow products that are relevant to succeed while allowing others to fail. A challenge therefore will be for a solution provider to determine what makes a product tick and what makes a product fail.

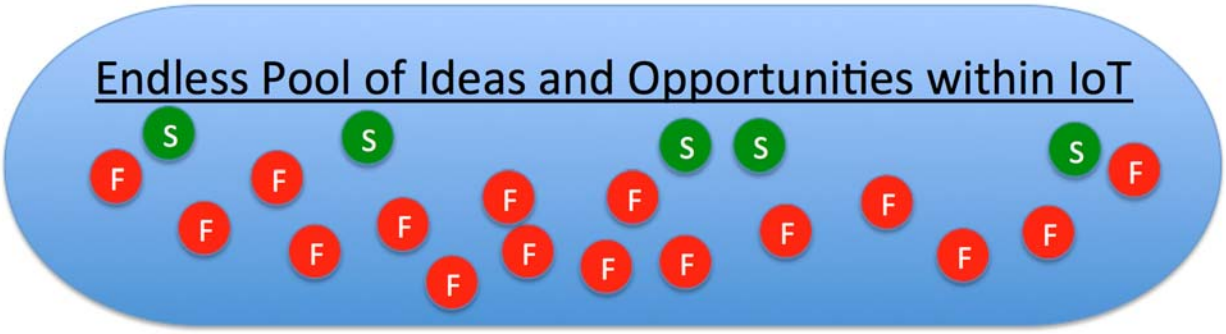

Figure 4 – Natural Selection of IoT opportunities

2. Visualizing the possibilities with IoT

There are several ways to visualize what is possible with IoT. Typically approaches to IoT are considered based on an industry vertical – security systems, home automation, senior care– and so on. IoT as a solution space is also often seen as distinct from the Internet of today. This section attempts to provide a rather different view of IoT, not as something distinct from the Internet, but rather as a superset of the Internet. It also takes the reader through a thought exercise that helps us get a better view of what IoT means and the potential that it has. It then tries to enumerate the various types of solutions that can be devised with IoT and the challenges therein.

2.1. Visualizing the home through an IoT filter

When we talk about IoT today and look for applications in the IoT space, we typically consider various individual industry verticals and the solutions that each of these verticals yields. One might look at wellness and talk about weigh-scales and blood pressure monitors that can be used to monitor person's vitals and look for biomarkers that signal the onset of various diseases. Similarly, one might look at the energy vertical and consider various ways to monitor energy usage within the home and thereby help individuals conserve energy.

What if we were to look at this differently? IoT essentially means ubiquitous connectivity, which is the same as getting everyone and everything connected. We therefore have the Internet of **everyone** talking to the Internet of **everything** (assuming 'everything' refers to the world of inanimate objects). Considering the home for example, which is where MSOs have a large presence, let's consider a case where everyone and everything within the home are connected i.e. reachable at any time. What we find then is that the

Internet of today, which is mainly the Internet of gateways, computing devices and smart-phones is but a subset of the Internet of Things.

We now have a situation where everyone in the home and every one of the folks that they are in interaction with are online, in contrast to the situation today where only a few members are online. For example, parents would know the status of their children at any time and be able to reach them and vice-versa. The mailman, maintenance folks and others interacting with an individual within the home would similarly have their status available at all times. The Internet of all inanimate objects within the home then brings everything else within the home online – irrigation systems, appliance, home automation systems and everything else.

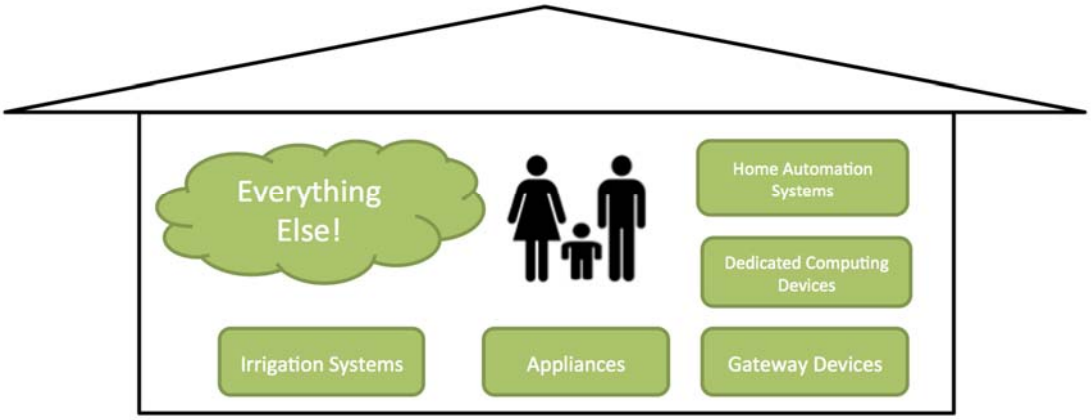

Figure 5 – The Internet Of Everything in the Home

We take this exercise one step further and look at all homes communicating with each other and entities that they are in contact with, and interesting possibilities start to emerge. We start seeing clusters and patterns based on persons, things and the association between persons and things. Person based clusters would include family, friends, work colleagues and maintenance folks and so on. Thing-based clusters would include appliances, entertainment systems, security systems, home automation systems and so on. We can also start talking about similar clusters that include both persons and things where both parties are actively required to accomplish a particular task, for example, a child trying to leverage a smart assistant to complete her homework.

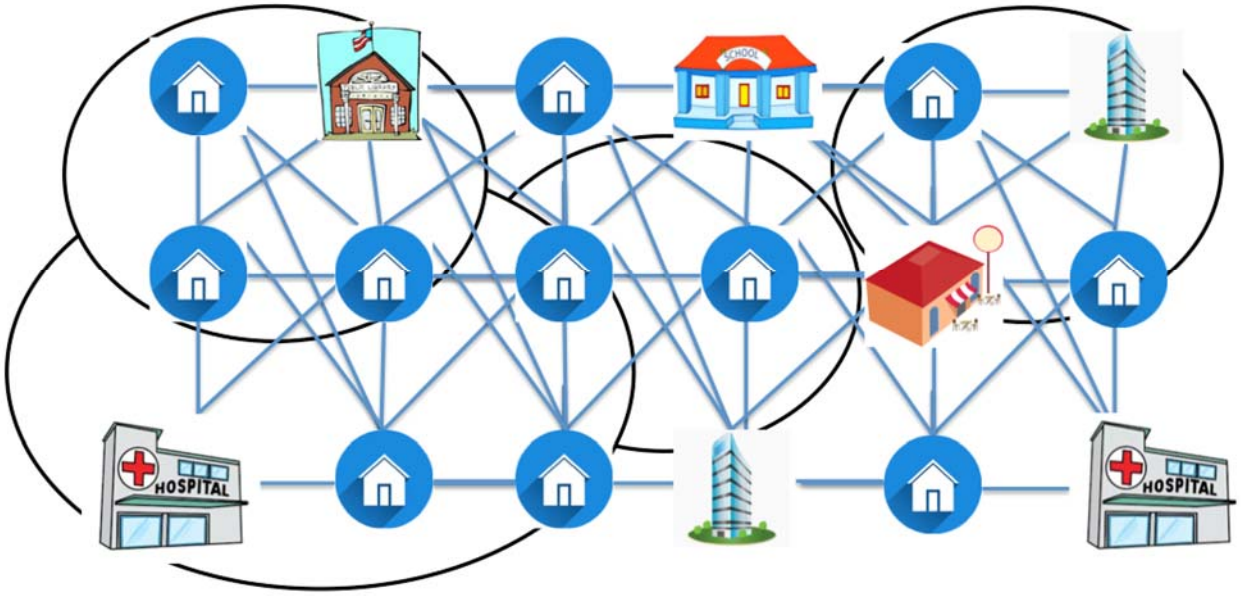

Figure 6 – Interconnections between the home and other entities

2.2. A look at some of the possibilities

In order to consider the full scope of what is possible, let us embark on a simple thought experiment. Imagine for a moment that literally everything in your home were truly connected. What if you were to enter a new home and decided that you would only bring things into the home if they are somehow connected and networked into the broader ecosystem of the IoT. To begin with, if you are in the home now, it might be worth looking around and consider everything that you see – books, clothes, shoes, time pieces, alarm clocks, calculators, pencils, pens, erasers, a stapler, shelves, chairs, tables and so on. Imagine that each and every one of these items has a way of being reached. The pencil for example is online and can let us know when it is time to be sharpened or can automatically re-order itself when it has almost run out of itself.

The more obvious types of groups that begin to emerge are

1. Internet gateways
2. Dedicated computing devices
3. Appliances
4. Energy consuming devices
5. Security Systems
6. Home Automation systems
7. Entertainment Systems
8. Automobiles

When we do a bit more searching, we find other less obvious groups like the ones below begin to emerge

1. Clothes
2. Books
3. Medical devices
4. Medications
5. Food
6. Kitchen Tools
7. Wellness
8. Carpets/Flooring
9. Household documents
10. Shelves, cupboards…
11. Doors, windows
12. Tables, chairs and furniture
13. Picture frames, vases
14. Toys
15. Personal hygiene devices

If we were just look at each of these specific groups, clothing for example, we find that each groups typically fits into a large ecosystem and is usually part of an existing value chain. We also find that a part of this value chain is already online, in clothing for example, clothing manufacturers, distributers and retailers are already online. The groups that emerge within the home were the only part of the value chain that was not online. By bring this group online, we find that the entire value chain is online. When we look at each of the groups that emerge in light of the value chain that they are a part of and when we try to figure out ways to leverage the entire connected value chain, we find that a floodgate of new opportunities is released.

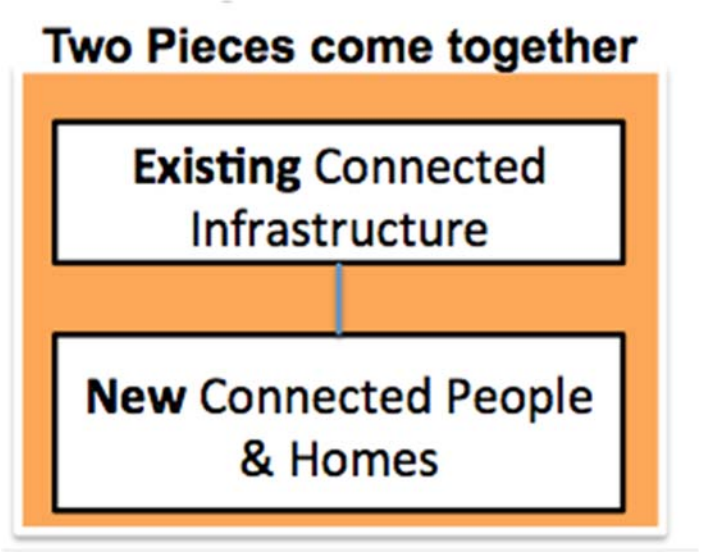

Figure 7 – Bridging the Value Chain - Extending existing services into the home

2.3. Some of the possibilities

One of the immediate benefits of bringing everyone and everything online is awareness. We become aware of what the status of everything is – location, condition and so on. We can also begin to

communicate and affect the state of everything. Some of the broader areas of possibilities that this reveals are

2.3.1. The Uberization of people and things

Everyone and everything can now be made available to each other when required. I could for example loan things that I do not use to a neighbor who needs it and similarly I would know if my neighbor had something that I needed and there would be a system to share things with each other. This is merely the extension of the Uberization of automobiles (*Uber*) and homes (*airbnb*) to everything else.

2.3.2. Redundancy management:

Awareness of everything within the home gives a new way to deal with redundancy. We always have multiple copies of things that we do not need within the home. Imagine you are able to pull up your laptop and are able to see exactly how many pencils, pens, books, screwdrivers that you have. When we are aware of what we have, we will realize that we have way more than we need. This allows for a new way to eliminate waste and conserve resources and money.

2.3.3. Just in Time management

When everything that we come into contact with is able to tell us its state and provides a means for us to be able to control it, this allows for us to apply concepts of Just In Time management (JIT) [3] to the management of the home. This is in fact already in use today, with Amazon's Dash service that allow people to re-order items within the home when they are run out. Eventually, JIT would be extended to every other aspect of our homes including clothes, appliances, books and so on. It would be a time when we would never have more than what we need. Think about the enormity of the transformations that this would affect upon each one of the industry verticals that are impacted.

2.3.4. Search

The ability to find everything within the home instantly also adds other interesting uses. At the minimum, this feature is essential to all the other scenarios for IoT within the home such as Just in Time management and Redundancy management. When considered in isolation, this belongs to the value chain of Search, where Search now extends from the world of our things on the Internet and our emails and into our home – an end-to-end integration of Search ecosystem. The ability to find things within the home and analyze this in relation to every other thing and the Internet that we know today can help flesh out interesting applications and use cases.

2.3.5. Automated product/person recommendations

We have seen a transformation in the way product recommendations are delivered. While previously we were dependent on product marketing and word of mouth to be made aware of how well a product performed in relation to others, we have since come a long way. Online websites such as Yelp that allow people to post product recommendations have been tremendously helpful in getting unbiased opinions of how products perform in relation to each other. As products begin to get connected and advertise their status, it is likely that person-based recommendations of products will change to machine-based recommendations that automatically tap into a product's status and derive insight into the working of the product. For example, it will be possible to know when the product was purchased and when it stopped working. It will also be possible to derive how useful the product was by looking at the status of how

often it was used. This information can be combined to post automated product recommendations. When automated recommendations from all other users of the same product are combined, there is likely to be a more objective means of determining a product's performance.

2.3.6. Accelerated natural selection of products

The ability to determine a product's performance, as shown in the previous section, allows for the accelerated determination of what works and what doesn't. While previously, poorly built products could survive much longer due to the time taken for the quality of the product to be made known to potential users of the product, with automated and objective recommendations, the status of how a product works will be made available in real-time to everyone. This way everyone will know how products perform at any given points in time. This knowledge in turn helps accelerate the demise of bad products and the success of good ones.

2.3.7. Targeted Marketing

As awareness of people and things rise, so too will be the ability to understand the needs and wants of individuals. This knowledge allows for much more granular and targeted marketing campaigns where the only things being advertised to people are their needs and wants. This puts an end to the unceasing onslaught of junk mails and unsolicited advertising campaigns that rely on the probability that a tiny percentage of folks would succumb to these campaigns. This would result in millions of hours of productivity gains for us as a whole. According to 411pounds.org, an environmental organization, more than 100 million trees can be saved each year by just getting rid of junk email [4]. The move to targeted marketing campaigns will go a long way to help preserving our environment.

2.3.8. Integration within the value chain

As mentioned in earlier sections of this document, the Internet of Things, helps bring online the last pieces of every value chain that stretches into the home. There is a part of this value chain, the one not in the home, that is mostly already online. Bringing the entire value chain online, leads to tremendous opportunity by enabling the end-to-end automation of the entire value chain through services such as JIT management and the ability for various players within the value chain to better understand and optimize the costs and revenue contribution of every element within the value chain.

2.3.9. More data for predictive modeling

One of the more immediate consequences of bringing the Internet of Everything online is the variety and scale of data that we now have on all these things. Machine learning systems can be leveraged to try to deduce patterns within this data and establish models that can predict our needs and wants and tailor the ecosystem around us accordingly. In the wellness industry, the continuous monitoring of a person's vitals and search for biomarkers can help predict the early onset of disease leading to early intervention. According to a study sponsored by Excellus BlueCross BlueShield in NY State, about 9 out of 10 visits to the ER for 10 common conditions such as ear infections and headaches, were considered potentially preventable. This results in a $1.3 billions dollar preventable cost just in the state of NY alone. When extended to other states and other more costly conditions, the potential for savings in healthcare alone is enormous.

2.4. Challenges with IoT

While opportunities abound with IoT, so too do the challenges. This section reviews a few of the key challenges facing developers of IoT solutions.

2.4.1. Identification and Authentication

As things start going online, there will need to be a way to uniquely identify and authenticate them. While the Internet of today has a system of IP addresses and URLs to identify devices, there isn't a standard universally accepted for the Internet of Everything, although there are several attempts at trying to establish a common scheme for identifying these devices. The main challenge in a universal scheme to identify things in the IoT domain is that all of these devices do not have the same sets of capabilities. A related challenge is the ability to distinguish multiple instances of the same device types where more than instance of the same device exists.

While some devices such as home entertainment systems tend to be larger and come with larger processing power, others such as door and window sensors are of much smaller footprint, are expected to be cheaper and come with relative much less processing power and storage. A technology such as IPv6 for example that would meet the needs of larger devices will therefore be hard-pressed to run one of these smaller, less powerful devices. Several standards bodies such as the Open Connectivity Foundation (OCF) are looking at protocols such as COAP that tweak popular Internet protocols such as HTTP to make them run on less performing devices.

Device authentication has also been a challenge given that device authentication typically requires a certain degree of cryptographic code to be present on the device. Cryptography also tends to be processor intensive and it is therefore challenging to find a universal way to agree on an authentication standard for all devices in the IoT domain.

2.4.2. Onboarding

Onboarding refers to the ability to recognize the presence of a new device within the home and the ability to provision that device and make it a part of the system of connected things within the home. For example, allowing for a newly purchased light bulb to immediately and seamlessly become a part of the home automation system within the home as soon as it is plugged into a socket. Two key aspects of device onboarding are device discovery and device provisioning. Device discovery allows the device to make its presence known to IoT controllers (or hubs) within the home. This requires the device to recognize the latch onto the home network and announce its presence. Device provisioning allows for the device to be initialized with an initial configuration relevant to that home. For example, a light bulb may be configured with a friendly name and other configuration such as security parameters and default set of rules around when to go on and off.

Device onboarding requires that IoT devices share a common identification scheme and speak a common language. The fragmented nature of the IoT landscape, with numerous proprietary protocols and standards is far from the ideal and much work remains to be done in this area. A big reason for this fragmentation are incumbents who have invested in proprietary standards and reluctant on moving to broader standards. The Internet also experienced similar fragmentation during early stages of its growth. The exponential growth of the Internet started with the universal acceptance of the Internet Protocol (IP), the Unified Datagram Protocol (UDP) and the Transmission Control Protocol (TCP). Similarly, the inflection point for IoT is also likely to take place when IoT solution providers are able to converge on a standard

protocol as well. When solution providers have the assurance that the IoT infrastructure is deterministic, it helps unleash a flood of creativity that gives rise new and innovative applications.

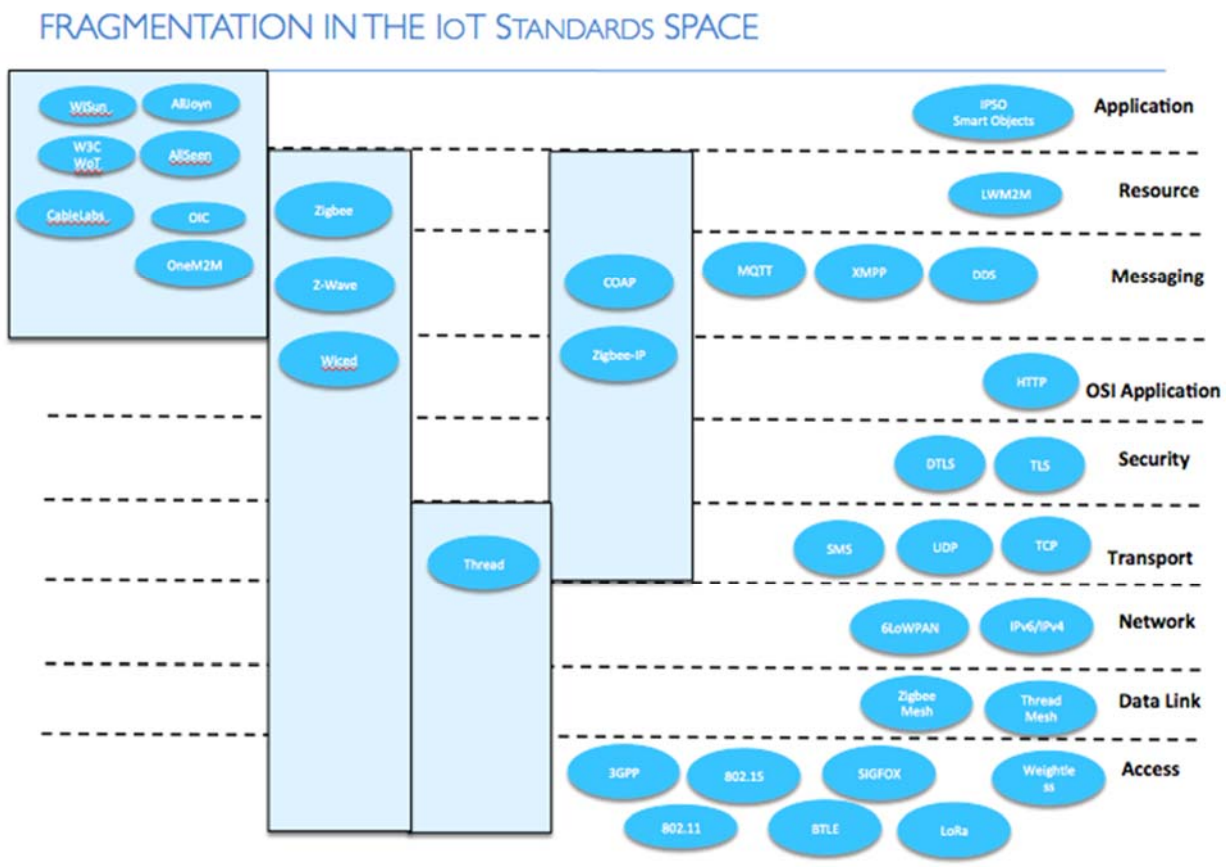

Figure 8 – Fragmentation of the IoT protocol landscape

2.4.3. Organization

As numerous devices come online, we will need to devise ways to organize all of these devices and the information that they possess in way that is intuitive and easy to understand. There are several dimensions along which information can be organized and even within each device, information needs to be organized and presented in a way that makes sense to the user and not force the user to drown in a barrage of noise and confusion. Some of the dimensions along which devices and their information can be analyzed are with respect to priority i.e. how important is this device to the user or how critical is the information to the user. Other dimensions may be based on device classes – fitness, security etc. or based on the associations of users to devices; for example, all the things that I use within the home can be grouped together.

2.4.4. Ethics

Ethical issues abound as everyone and every thing allow themselves to be discovered and communicated with. Government agencies can leverage IoT to control and monitor every aspect of our lives. Machine

learning technologies allow for discovery of additional information by extrapolating available information. For example, a frequent trip to the doctor by an individual may lead someone to deduce that there is a serious medical condition. Frequent exercise by certain individuals may result in differential treatment to those individuals by their employers as opposed to someone who may have an unavoidable chronic condition and unable to maintain a similar routine. Advances in behavioral management can cause marketers to attempt to change our behavior in ways that align with their interests as opposed to allowing us to live life on our terms. This is just a short list of the challenges that ethical challenges that one would face. I posit that we will be confronted with even bigger challenges, the kind that is hard to imagine in the present day and age. The Internet brought with it the disease of accelerated radicalism of individuals, child pornography, cyber bullying and other scourges. The Internet of Things will likely bring even bigger challenges and there is much to be worried about as this next stage of technological evolution unfolds.

2.4.5. Privacy & Security

The Internet with its limited exposure to the world has itself been inundated with privacy and security issues. The Internet of Things would bring trillions of other devices online and the concerns on privacy and security that we have today with respect to the Internet would pale in comparison to that of IoT. Device hacks can compromise the security of our homes, the operations of necessary medical devices within the home and the automation of various aspects of our lives. When the locks in our home are exposed via the Internet, it exposes the home to malicious individuals who may want to break into our home. Similarly, when critical home-based medical devices such as dialyses machines or pacemakers are online, it threatens the lives of individuals that need these devices and could open the door for malicious individuals to remotely commit harm. Knowledge of other devices with computing power, could allow people to take control of the distributed computing power of a trillion devices to attempt to crack sophisticated cryptographic algorithms and compromise our privacy and security, both of which depend on these algorithms. While current mechanisms to secure the Internet are somewhat reliable, given that all IoT devices do not have the same processing and storage capabilities, we are hard pressed to come up with ways to make privacy and security work in a reliable way across all IoT devices.

2.4.6. Device Association

Device association refers to our ability to associate devices and their operating rules with users of these devices. This is typically implemented through user profiles, that allow for knowledge graphs to be built that capture each individual user, their associations and the associations between all users. This results in a massive web of interconnected users and devices that in turn allows for the derivation of further second and third degree associations and so on. For example, it allows for associating devices to entities. A bed could belong to a master bedroom and an individual; a car could belong to one or more individuals within the home and an entertainment set could belong to a television and so on. The management of device associations therefore enriches the context in which the device operates and sets guidelines around device ownership and user preferences.

2.4.7. Robust Connectivity

Ubiquitous connectivity results in an exponential growth in the number of connected devices within the home. As more devices come online, it will be important that the underlying connectivity platform is robust; otherwise, the number of connectivity issues will likewise grow in an exponential manner, challenging our ability to effectively manage these devices. As our dependence on connectivity increases

and the robustness of the network decreases, the failures that result will leave us overwhelmed and incapable of controlling those aspects of our lives that we have taken for granted all along. An example is perhaps a failure of a door lock to open the door for us when we arrive at our home, the failure of an appliance that needs to be serviced, or the failure of a critical food ingredient to place an automated refill requested when nearing completion. All these can leave us utterly confused and greatly unproductive, which is quite the opposite of what IoT has sought to accomplish.

2.4.8. Simplicity

As more people come online, there will be the ever-pressing need to keep interactions with everyone and everything simple. To put this in perspective, one can consider the users of the Internet of today as the geeks in the tomorrow's IoT world. The world of IoT brings babies, children, aged people, and the sick and disabled, people of various cultural backgrounds, languages and countries together. Given the diversity involved, there is going to be little that they all share in common. Simplicity with IoT is the ability to operate within that thin sliver of commonality yielding interfaces and interactions that are more or less universally intuitive and understood. This is probably one of the more challenging problems with IoT and would likely involve a combination of things that we are familiar with and latest advances in natural language processing, presence detection and so on.

2.4.9. Data Management

As stated previously, IoT brings petabytes of data into play. While this data is empowering, the management of all this data and the demands on storage and processing power are enormous. We will need to rationalize the processing and the storage of this data in order to ensure there is a cost-effective way to manage all this data. There are a few options that one can think of. One option involves filtering data at the source and only sending processed or relevant data upstream. This filtering could be done either on the originating device or in another device closer to the originating such as a gateway device. Another option may involve classifying data into real-time analysis candidates versus storage candidates. Data is strictly real-time, may only incur processing overhead and can be discarded as soon as it is processed and necessary information is derived from that data. Either way, there will be data loss involved and the most effective data management methodologies will prioritize and only try to process or store data that best balances insight and cost.

2.4.10. Rules Discovery and Management

Rules will be a critical part of the IoT framework. They are important because they enable greater automation of IoT devices. Rules can range from simple to sophisticated. Simple rules may look for boundary conditions or thresholds and take some action when events take place either within or outside these conditions. More sophisticated rules allow actions that are more complex. For example, a weigh scale may try to detect for a rapid gain in weight, where rapid may be a weight gain of more than 10 pounds in 3 days, to flag potential signs of an imminent heart failure.

While rules are typically configured manually or through the use of defaults, an even more challenging scenario is the discovery of new rules. For example, a security system may detect that there is no one in the home and may reduce the indoor heat or turn off the cooling. Similarly, the home entertainment system may detect that you turn on your television at 6am in the morning for the daily news and may automatically turn it on and tune to the News channel next time you are in front of the television at 6am. This ability to intelligently discover new rules will become essential as the number of devices that are

online significantly increase. When this happens, manual configuration of rules will no longer be an option.

2.4.11. Solution Discovery

Perhaps the biggest challenge of all is for IoT solution vendors to determine which opportunities to pursue and which ones to reject. The permutation of device classes, people, industry verticals and applications yields a seemingly infinite number of opportunities. How is one supposed to rationalize the endless set of opportunities and pick the ones that have the biggest likelihood of success?

3. A framework for pursuing the right IoT opportunities

This section proposes one possible framework for identifying opportunities within the IoT space. It proposes a strategy for identifying candidate opportunities, the importance of understanding the players involved by looking at the value chain to which the opportunity belongs and lays out a step by step plan to go about the process of gauging each opportunity.

3.1. Strategies for finding candidate opportunities

One approach to determining the right set of candidate opportunities to pursue in the IoT space is to look for opportunities that lie within the confluence of the below three areas

- Service must meet user needs
- Services must leverage an MSO's strengths and core competencies
- Service must result in substantial cost reduction or new revenue opportunities for the MSO and one or more players within the value stream.

3.1.1. User Needs

Generally, user needs fall in one or more of the below areas. Opportunities can be explored based on their ability to meet these needs and the relative cost savings or new revenue projections that result to the MSO and the user.

- Cost Savings
- New Revenue Generation Opportunities
- Wellness Goals
- Safety Concerns
- Security Concerns
- Privacy Concerns
- Convenience
- Productivity

The below picture expands on various things that users would be concerned with to help motivate the process of opportunity discovery.

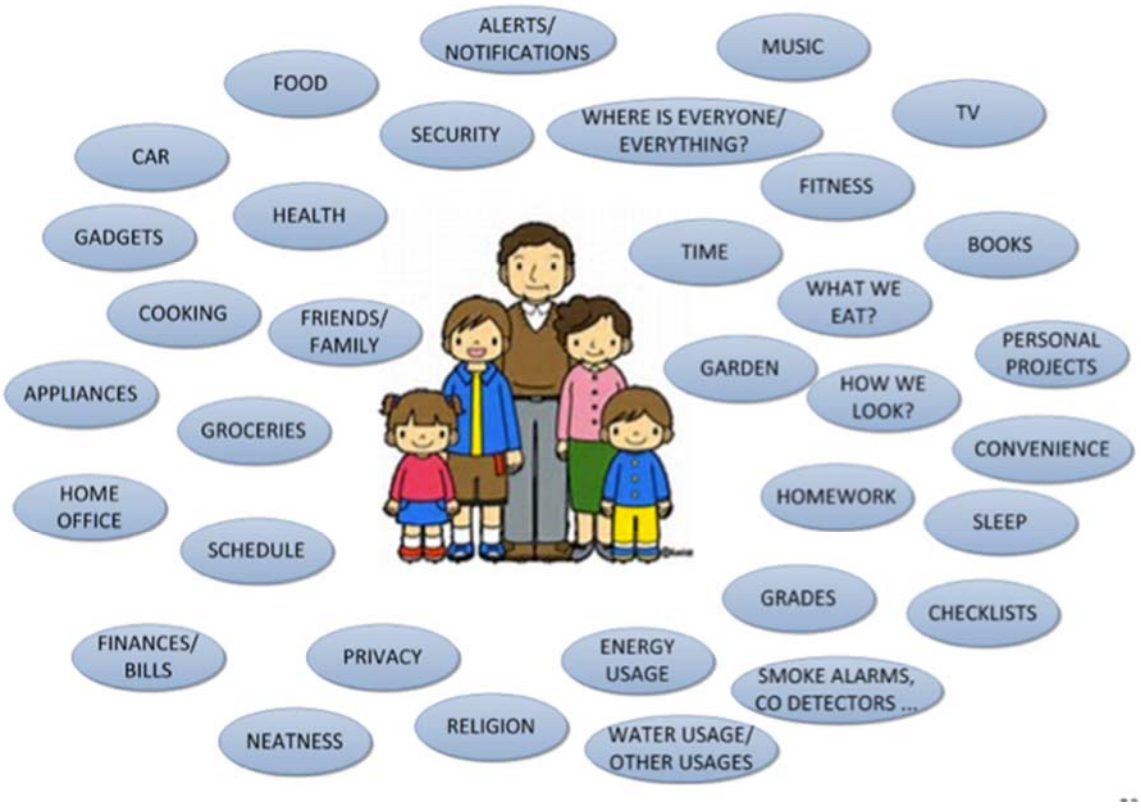

Figure 9 – Needs of users within the home

3.1.2. MSO Strengths

This section enumerates an MSO's strengths and core competencies with a similar attention to motivating the discovery of new IoT opportunities.

- Billing Systems
- Broadband Infrastructure
- Cell Backhaul
- Truck Rolls/Tech network
- Emergency E911 System
- Customer Support Systems
- Virtual Machine Infrastructure
- Field offices
- Demonstration Labs
- Content Distribution
- Content Production
- Sports Stadiums
- Remote Monitoring and diagnostics
- Technology Development
- Headend & fiber optic network

- Data Centers
- Large employee base
- IP video infrastructure
- Subscriber base
- Warehouses/Staging Areas

3.2. Understanding the players involved

We now turn our attention to the various players involved with each candidate opportunity. As the evolution of IoT accelerates, there are likely to be three broad groups of folks that would pursue the development of IoT solutions. These groups are (a) *individuals and communities* (b) *the Government* and (c) *Corporations*.

Individuals and communities are mostly non-profit and typically fueled by personal stories. They are looking to leverage IoT to further their personal or community goals. The avenues for this group to express itself will most likely be through opensource development efforts or personal projects. Governments are typically motivated by the need to improve operational efficiency, improve security, communications, outreach and the figuring out new ways to control costs. Corporations will be motivated by the need to either control their costs or improve their revenues. As various forces embark on their quest to build new solutions involving IoT, it will be critical to ensure that the data and the knowledge gained from these various endeavors are shared so that these learnings can be used to help further evolve the IoT ecosystem.

3.3. IoT as a natural extension of our core competencies

MSOs must also understand how IoT fits into their existing infrastructure and service offerings. The below block diagram attempts to depict core capabilities and services that MSOs typically possess and overlays new capabilities required for IoT on top of the existing capabilities. In most cases, it is fairly obvious that IoT is a natural extension to our core competencies.

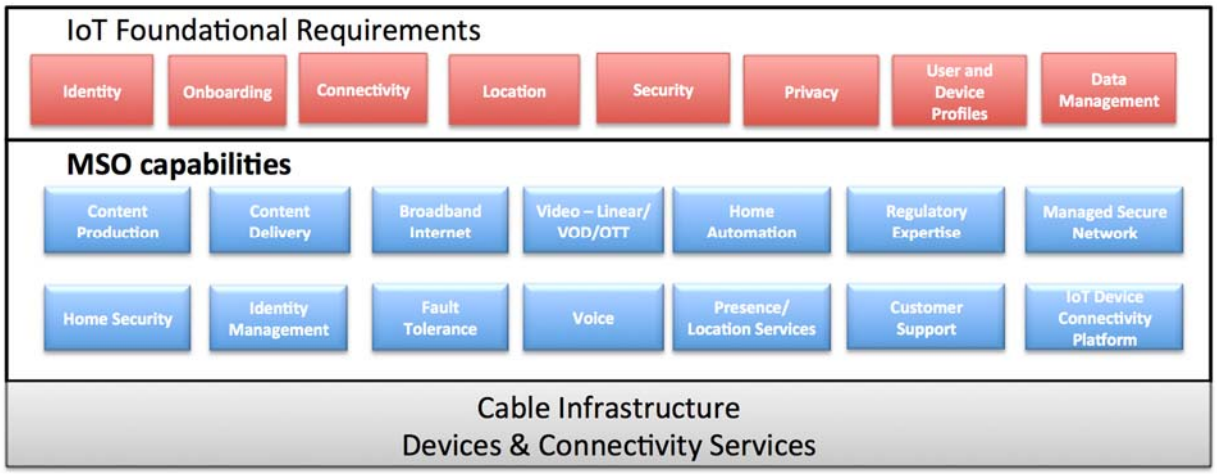

Figure 10 – MSO core competencies in relation to IoT

3.4. Broad monetization strategies

There are two broad strategies for an MSO to monetize the IoT space. The first is as an IoT Systems Integrator and the second is an IoT solutions provider.

As an IoT System Integrator, an MSO can use their devices as IoT hubs allowing other IoT service and application providers to use our infrastructure to deliver their services. MSOs can play a critical role here by owning the pipe that brings IoT services into the home and becoming a part of the service delivery value stream. Given how active we are in the technology domain, we will also be able to play a big role in helping advance much-needed standards in this space as standardization tends to drive down costs and allows us to focus on higher layers of functionality including service offerings. Regardless of whether we intend to pursue the IoT services space, it will be critical for us to establish our presence as an IoT system integrator; especially given that our Internet gateways are already passively involved in the delivery of IoT services. Monetization opportunities for the IoT system integrator is however limited since we do not really drive product differentiation and have little control over the actual value stream itself.

3.5. A framework for identifying the right opportunities

Now that we have looked at ways to determine opportunities and understand the players and monetization strategies, the next section proposes a simple framework to gauge the success of each opportunity.

The proposed framework involves the below six steps

1. Identify the problem domain and a broad statement of the opportunities.
2. Determine the participants, controllers and the pain-points within the value chain for the selected problem domain
3. Enumerate the set of candidate opportunities
4. Perform a feasibility analysis to determine viability for each candidate opportunity
5. Determine the ROI and the probability for the candidate opportunity to succeed.
6. Pursue or reject each candidate opportunity based on a set of predefined acceptance criteria.

4. An Hypothetical Case Study in Energy Management

This section examines a real world example involving opportunities related to energy management within the home and explains how the framework proposed in the previous section can be applied to these opportunities.

4.1. Determining the problem domain and a broad statement of the opportunity

The domain for exploring candidate opportunities is the energy domain. The goal is to use knowledge of energy consumption within the home in order to drive savings for users.

4.2. Determining the players, pain-points and controllers within the value chain

The value chain extends from energy producers, to energy distributors to consumers to devices that consume electricity and lastly to devices that monitor energy use.

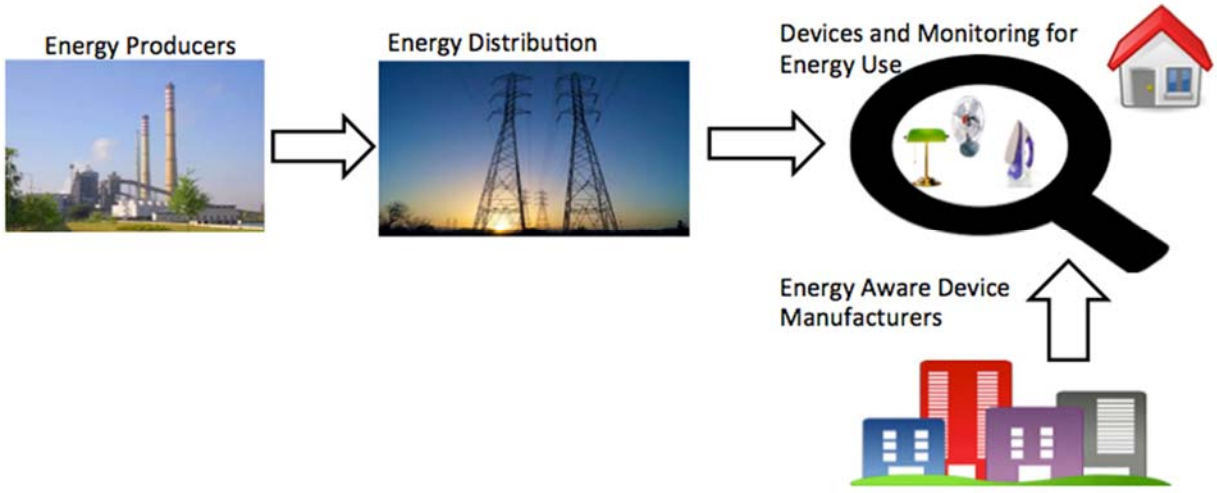

Figure 11 – The Energy Management Industry's Value Chain

Typical pain points for users in this space are controlling energy costs, the inability to accurately monitor usage and reduce wastage. Another need is convenience, where users may want to turn the heat on before they actually get home so that the temperature is comfortable by the time they are inside. By bringing connectivity to devices within the home, IoT allows for greater insight in energy usage. This could result in innovative applications such as the ability to detect wasteful usage or the ability to intelligently turn devices on in advance based on predetermined requirements.

4.3. Enumerate the set of possible opportunities

For the purposes of this case study, the following opportunities are considered.

1. Allow users to leverage price fluctuations by redistributing energy consumption to minimize usage during peak hours
2. Optimize energy usage within the home by detecting and stopping wasteful usage
3. Correlate data on home energy usage to other features such as presence detection, intruder alert and theft of energy
4. Provide a platform for utility companies to add other value-added services such as the purchase of stored energy within the home
5. Real-time comparison of various available energy options – thermal, solar etc.

4.4. Feasibility Analysis with players in the value chain

The next step is to perform a feasibility analysis of each opportunity. Let us consider the specific opportunity involving allowing users to leverage price fluctuations by redistributing energy consumption to minimize usage during peak hours.

We will need to work with other partners in the value chain to try to understand the following

- Does there exist a mechanism to obtain in real-time or otherwise price information for various times within the day? Are Utility companies willing to share this information?
- Are there sufficient standards and protocols in this space to allow for ease of implementation and interoperability?
- Is there a sufficient quorum of energy-aware devices or available energy monitoring devices to allow for meaningful monitoring of energy use within the home?
- Will an MSO have sufficient standing relative to other players within the value chain so as to drive product differentiation and thereby exercise better control over profits and avoid substitution?
- If no, is there an acquisition or partnership opportunity that allows for this
- How competitive is this space and what are the barriers to entry?
- What is the relative value of serving as System Integrator versus being a Services Provider?

4.5. Determine the return on investiment (ROI) and the probably of success for each opportunity

The next is to elaborate on the set of opportunities within the energy domain and attempt to size each opportunity in terms of revenue growth or the cost reduction opportunity.

Table 1 – Sizing up candidate opportunities and their probability of success

List of candidate opportunities	New Revenue or Cost Reduction potential (ROI)	Probability of Success
Allow users to leverage price fluctuations by redistributing energy consumption to minimize usage during peak hours.	✔	✔
Optimize energy usage within the home by detecting and stopping wasteful usage	✔	✔
Correlate data on home energy usage to other features such as presence detection, intruder alert and theft of energy	✔	✔
Provide a platform for utility companies to add other value-added services such as the purchase of stored energy within the home	✔	✔
Real-time comparison of various available energy options – thermal, solar etc.	✔	✔

4.6. Pursue/Reject the opportunity

The final step in the process involves the selection of one or more opportunities based on the ability of that opportunity to meet our success criteria. Success criteria could be a function of several factors including risk aversion, payoff potential and so on.

Conclusion

IoT is the next stage in the evolution of communication technologies. Given the exponential growth in technology it is obvious that the growth of IoT will be no less different. The explosive growth of IoT will bring with it numerous opportunities and numerous challenges as well. Organizations that get involved early have the opportunity to take advantage of this ongoing transformation and secure beachheads that will reward them with early mover advantages and significant advantages over the competition.

The core competencies of MSOs are well aligned with those required for either IoT service integrator or IoT service provider offerings. MSOs can leverage this existing arsenal of competencies to innovate and bring new solutions into the IoT space that can help significantly drive revenue growth and cost optimizations.

Abbreviations

IoT	Internet of Things
CMS	Center for Medicaid and Medicare Services
JIT	Just in Time management
IP	Internet Protocol
TCP	Transmission Control Protocol
UDP	Unified Datagram Protocol

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