Pantas and Ting

Sutardja Center for Entrepreneurship & Technology

Berkeley Engineering

Our Hypothesis



Keley Sutardja Center for Entrepreneurship & Technology Shattuck Ave 11th Floor, Berkeley, CA 94704 || s UNIVERSITY OF CALIFORNIA 2150 Shattuck Ave 11th Floor, Berkeley, CA 94704 || scet.berkeley.edu

Ber

Current state of home automation IoT enabled devices and what is the future direction of that market. Understand the current consumer and vendor pain points and how they handle them.

Business Model (15-20 mins presentation)

Consumers

- Single application/interface to discover, configure and manage IOT devices.
- Single application/interface to provide data analytics from various devices. User can either select "automated learning" based on the feedback loop, or "manual override" to refine configuration.
- Sell monthly or individual service plans for the maintenance of devices and appliances.

Businesses

- Provide turn key platform to launch IOT devices. This provides device administration, software updates and diagnostics.
- Businesses can service their customers using this platform (transaction fees would be paid to the company).

Marketplace for 3rd party/vendors

- Vendors can bid on the service need arises on the appliance or device. Consumers can choose most competitive bidder after reviewing their rating and other consumers experience.
- Collaboration on themes with other consumers to synchronise related devices. For e.g. synchronize blinds and lights with time clock and weather outside.

1) Existing Landscape (using data points from today)

Introduction

The global Internet of Things market will grow to \$1.7 trillion in 2020 from \$655.8 billion in 2014, research firm IDC says, as more devices come online and a bevy of platforms and services grow up around them. The firm predicts that the number of "IoT endpoints," connected devices such as cars,

refrigerators and everything in between, will grow from 10.3 billion in 2014 to more than 29.5 billion in 2020.

Disparate devices will likely need to be managed by the same infrastructure, underscoring the need for common standards.



¹A networking of physical objects via embedded devices that collect and/or transmit information. Source: Forecasts derived from ABI Research; expert interviews; Gartner; IDC; McKinsey analysis

Connected Home Shipment and Market size (Source: BI Intelligence)

Homes around the world are going to become smarter and more connected over the next five years.

• Forecast - global shipments of connected-home devices will hit 142 million units this year and rise to 1.8 billion units shipped annually in 2019. Compound shipments growth will top 67% annually over the next five years to 2019.

• In dollar volume, estimate that shipments of connected-home products will drive over \$61 billion in revenue this year. That number will climb at a 52% compound annual growth rate to reach \$490 billion in annual revenue in 2019.

For the purposes of this forecast, definition of connected-home devices includes all smart appliances (washers, dryers, refrigerators, etc.), smart home safety and security systems (sensors, monitors, cameras, and alarm systems), and smart home energy equipment like smart thermostats and smart lighting.

Existing Landscape - Connected Home Market Survey in America (Source: Mckinsey)

In the span of a few short years, connected devices have entered the home of million Americans, and are now poised for a new wave of growth. In this survey approx. 2,000 US households were asked for their view on connected homes. Here are some interesting facts from this survey.

State of the Market



Penetration of Devices



Value Proposition



Current buying factors center on Price, Basic Functionalities

Device Buyer

7

7



Service Buyer

8

8



Sutardja Center for Entrepreneurship & Technology Technical Report Willingness To Pay



Customers Willing to Pay More Than \$20/Month



Large Players in Home Automation

1. AT&T Digital Life

AT&T Digital Life (App with consolidated wireless adapter box - \$55/month and up) - AT&T's digital life home automation app integrates home security, home alarms with AT&T voice, TV and internet. It also has connected cars solution.

- 30 wearable devices connected to network
- More than 4 million connected devices on the platform
- Over 1.0 million fleet vehicle connected to network
- Over 684 K connected cars added to the network in Q1 2015
- AT&T also has smart city initiative (lighting, parking, transportation, safety, building)

<u>Strategy</u> - Using AT&T phone network to connect devices not within wifi reach

2. Samsung Smart Home

Samsung Smart Home - Connect and control all samsung devices with one app from your smartphone or smart TV.

Samsung announced ARTIK, an open platform comprise of hardware modules, software, and cloud services for connecting objects via WiFi, bluetooth and ZigBee.

Samsung acquired "Smart Things" and rolled out <u>SmartThings Open Cloud</u>, a cloud service based on Samsung's SAMI data exchange platform.

<u>Strategy</u> - Using Samsung mobile platform to connect all samsung devices, TV & appliances.

3. Amazon platform

Amazon platform - Amazon provides backend connectivity and compute to process data coming from various connected devices.

Amazon acquired **2Elementary** - providing device connectivity at scale, cross-communication, data brokering and storage. We also help companies make sense of the captured data by offering actionable data intelligence through predictive computational models and a configurable rules engine. <u>Strategy</u> - Using proven amazon AWS to provide backbone for IOT devices.

4. Apple HomeKit and HealthKit

Apple HomeKit and HealthKit - enabled devices connect to apple iOS and can be controlled through voice commands. Apple's strict security requirement on low energy bluetooth devices is a challenge.

<u>Strategy</u> - Using iOS ecosystem to connect devices.

5. Google Nest

Nest Learning Thermostat, Nest Cam (acquired DropCam), Smoke + CO Alarm, Linus Lock <u>Strategy</u> - Using Nest platform for home automation.

6. Philips Hue

Remotely controlled connected Lighting solution <u>Strategy</u> - Early player in connected lighting solution.

7. Xfinity Home

Home Security, Cable and Internet <u>Strategy</u> - Using existing cable and internet infrastructure to expand into home automation market

8. ADT Pulse

Home Security <u>Strategy</u> - Be expert in home security

Private Player (small) in Home Automation (Source: Inc.)

1. August Smart Lock.

August Smart Lock tops the list of home automation companies that protect your fort by offering an attractive, high-quality, and convenient automated door-lock system. The company understands that home automation technology has to be made easy to install and use, which is exactly what August Smart Lock does. It works with the existing deadbolt on a door and provides the power of an app to control home-lock mechanisms from your phone. The company even offers a Connect accessory that solves the problem so many connected locks experience of being out of range. Priced at \$250 plus \$50 for the Connect accessory, it delivers the most effective automated locking system based on the

value of its retrofit capability, user management convenience, and flexibility for both iPhone and Android devices.

2. Notion.

This home automation has got you covered on all fronts. That includes alerting you to the fact that a door is open (house door, gun door, refrigerator door, etc.), water is leaking, the lights are on, the temperature has changed, or a smoke alarm has sounded. Whether you want to control one room for \$129 (for one sensor and bridge) to multiple rooms for \$249 (five sensors and bridge), this incredible home automation company lets you set notifications on what alerts you want to receive on your iPhone or Android device. For such a technologically advanced home- automation solution, the five-minute set-up that involves peeling and sticking sensors and pairing with bridge and Wi-Fi is simply amazing.

3. Canary.

If you want a smarter and more secure home, Canary is your device. This product, unlike its competitor, learns about you over time and adapts to you. This product makes your home safer with a 147 degree wide-angle lens that you access through your mobile phone at any time. You can set off alarms or speak to a child if they are getting out of bed. It's perfect for Airbnb guests to monitor when a guest arrives or departs so that you don't have to bother them.

4. <u>Iris.</u>

Developed and sold by Lowe's Home Improvement Centers, this home automation product is easy to buy directly from the Lowe's stores, as well as simple to install and use. The fact that it comes as three different kits, including Comfort & Control, Safe & Secure, and Smart, allows you to customize it to fit your needs and existing home systems. The kits integrate with existing HVAC and security systems and adapt to your personal preferences for comfort and security. The company also offers responsive technical support and assistance for set-up and use. It connects directly to the internet through a modem but also works well with smartphones.

5. HomeSeer.

This award-winning home automation company has been recognized for its leadership in innovation and quality. This highly compatible home automation solution works with numerous media management applications, operating systems, web browsers, and security and HVAC systems. It works through automatic, manual, and voice control options so you can use it in multiple ways, whether you're home or away, through its remote access functionality. The company offers a comprehensive "one stop" online shop for all types of peripherals to customize the home automation

14

system to your needs and budget. This home automation system even monitors energy usage patterns and delivers reports that help you become more energy efficient.

5. Control4.

Just because it's known as one of the easiest home automation systems to use doesn't mean it's basic. Requiring professional installation, Control4 is a robust, scalable home automation system that can be hardwired or wireless, depending on your needs. It offers customization to include the home automation features that are important to you -- from whole house audio to a secure network of cameras to door locking mechanisms and light and temperature controls. You can use a touchpad, computer, or tablet device to control it from your home or a smartphone for remote access.

6. <u>Vera.</u>

When it comes to powerful, consistent remote access capability and dependable technical support, Vera tops the list of home automation companies. Although its features list may not be as extensive as others, the fact that its software can connect with any web browser or Android and iOS smartphone app means maximum control when you are away from home. The technology also allows for programming to randomize when lights go on and off to deter thieves that often track this information. This home automation system is compatible with many types of cameras and motion detectors as well as peripheral items like smoke detectors, door sensors, and light bulbs, which can then be controlled through its powerful remote functionality. It has four native hardware controllers that fit different types of homes and lifestyles.

7. Savant.

Geared toward Apple users, this home automation company offers a low-cost solution for dynamic control over your domain. It runs on Mac OS X systems as well as iOS smartphones and tablets and the iTunes media player. Requiring professional installation, this sophisticated automation system controls all aspects of your home, including opening and shutting doors, randomizing lights to come on and off at various times, setting your coffee pot to brew, and running your security and HVAC systems. Its powerful remote access system allows it to run from your office, the next state, or from any corner of the globe, so you can let your house (and thieves) know you're present in the home.

8. <u>Wink.</u>

This relatively new home automation solution is the brainchild of Quirky, an online invention platform, which works to continually innovate existing technology to make life even more convenient and secure. It's easy to use, compatible, and relatively inexpensive for the power it provides. Using a hub to connect to Android and iOS devices through Wi-Fi or Bluetooth, it sets up in minutes. As an alternative to the hub, it also offers a touchscreen device in the home that replaces the need for

standard light switches. This intuitive home automation system thinks for you, with a robot that can flash a home's lights when the smoke detector goes off or offer shortcuts to speed home automation controls. Since it does not offer all the functionality itself, the Wink system is compatible with other types of smart home technology, including products from Nest and Lutron.

9. **Ivee**

Voice Controller home hub - competes with Amazon Echo

2) Technology (Fate)

SECTION 2- TECHNOLOGY

The connected home is fast becoming a reality. As lower cost communication networks spread, the cost of hardware falls, new business models emerge and smartphones become commonplace, vendors are using wireless connectivity to enhance security systems, energy meters, household appliances, wearable devices, and healthcare monitors. These connected devices are part of the building blocks of the Internet of Things (IoT). They are evolving and quickly changing how businesses and consumers conduct day to day activities across sensing, communication and management layers.

Today manufactured devices are becoming smart devices through the addition of sensors and connecting to the internet to send their data to a cloud for processing. Once the data has been gathered in the cloud, application actions can be taken through remote command and control functionality through an application portal using intelligence decisions provided by the consumer. Finally, augmented behavior using Big Data to drive this management layer is possible to make things happen as the customer would have chosen with predictive analytics.

KEY COMPONENTS-

1- Sensors.

A sensor converts a non-electrical input into an electrical signal that can be sent to an electronic circuit. There are three primary factors driving the deployment of sensor technology: price, capability,

and size. As sensors get less expensive, powerful, and smaller, they can be used in a wider range of applications and can generate a wider range of data at a lower cost.

Three factors are contributing to the growth of adoption of sensors in IOT devices: price, power and size. The price of sensors has dropped over last years as shown in Figure 1. As they get cheaper, they can be used in more and more devices and in broader applications.

\$25 \$22.00 \$20 \$15 \$10 \$5 \$1.40 \$0 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014

Figure 1 – Sensor prices over last 25 years

Source: Rob Lineback, IC Insights Inc. "The market for next-generation microsystems: More than MEMS!," http://itac.ca/uploads/events/execforum2010/rob_lineback_10-6-10-2.ppt, June 10, 2010, accessed January 28, 2015; Lee Simpson and Robert Lamb, *IoT: Looking at sensors*, Jeffries Equity Research, February 20, 2014, p. 4.

Note: Prices shown above are average selling prices for image sensors and accelerometers.

Graphic: Deloitte University Press | DUPress.com

Sensors are becoming more powerful as its becoming part of system of microprocessors, modems, power sources. Over the last 20 years power has doubled every 3 years (see Figure 2)

Figure 2 - Computing speed increasingly becoming more powerful



Source: E. R. Berndt, E. R. Dulberger, and N. J. Rappaport, "Price and quality of desktop and mobile personal computers: A quarter century of history," July 17, 2000; ITRS, 2002 Update, *On-chip local clock in table 4c: Performance and package chips: Frequency on-chip wiring levels—near-term years*, p. 167; Deloitte estimates.

Graphic: Deloitte University Press | DUPress.com

Also, there has been fast growth in reducing the size of sensors so that there can be more of them embedded in smartphones and wearables.

Even though sensors are now small, more powerful and cheap, challenges and potential solutions remain. These include power consumption, data security and interoperability.

Power consumption can come from in-line or batteries. In-line is expensive for many devices and batteries may work but need to solve battery life, charging and replacements. One solution is efficiency improvements that need to continue to extend the life on batteries and reducing cost of replacements and charging.

Data security starting at the source with encryption seems like a logical choice to provide security across entire signal path. But processors relatively low power, low memory and power consumption make them not ideal to solve the security issue at this layer.

Most sensors systems are proprietary to one vendor and are designed for one application use case. This leads to interoperability issues that need to be addressed by lightweight communication protocols to facilitate communications between sensors between vendors.

2 Networks.

Data from sensor signals needs to be connected to the internet over a network and sent to other locations for aggregation and analysis. The IOT requires a unique name for each device. Internet Protocol version 6 was designed for superior scalability and the adoption of ipv6 is key for the IOT. Although alternative solutions like mesh networks supported by Threads alliance members Nest and Samsung can connect devices without ipV6 being directly offered to each individual object.

The choice of which network technology depends on range needed for the application. Within a room, devices can use Personal Area Networks (PAN) technologies like ZigBee or Bluetooth. Data transfer rates and energy requirement are also key when selecting the best network technology (see Figure 3)

Bluetooth and Bluetooth low energy (BLTE) is known for ability to transmit over short distances in PANs. BLTE deliver higher energy efficiency when compared to the original Bluetooth. But higher energy comes at the cost of data rates. BLTE supports 260Kbps while Bluetooth supports 2.1 Mbps.

Worldwide Interoperability for Microwave access (Wimax). Wimax2 offers maximum data speed of 1Gbps compared to 100Mbps by Wimax.

Long term evolution (LTE) is a WAN technology that offers up to 300 Mbps. LTE-Advanced now can go up to 1Gbps and is referred to as a true 4G technology. Due to its high bandwidth and low latency is one of the most promising for IOT applications.

	Personal area network (PAN)	Local area network (LAN)	Wide area network (WAN)
Wired connections	USB	Ethernet	Not applicable
Wireless connections	Bluetooth, ZigBee, Near Field Communication, Wi-Fi	Wi-Fi, WiMAX	WiMAX, weightless, cellular technologies such as 2G, 3G, 4G (LTE)

Figure 3- Network classes with examples by connection type

Note: A few technologies can work in more than one network type depending on the range of the networking device used. For example, Wi-Fi can provide connection within a house (PAN) as well as within a building (LAN).

Source: Wenyuan Xu, Introduction to computer networks, Department of Computer Science and Engineering, University of South Carolina, www.cse.sc.edu/~wyxu/416Fall09/slides/Chapter1_Info.ppt, 2009, accessed March 12, 2015.

en an a anna a anna an an a

Network needs of the future IOT will need a range of different technologies. Wi-Fi technologists already are working on 802.11ah (Wi-Fi on ISM bands below 1 GHz) to tailor it for infrastructure-independent ad-hoc, mesh networking and longer-range control of sensor networks.

One thing about the connectivity needs of the future IoT market is clear—it is so diverse, large and cost-conscious that a range of different technologies will be needed (possibly including WAN, LAN, WPAN, WBAN, etc.), and one size will not fit all. And disruptive wireless network technology like what Weightless (weightless.org/) is developing may still take hold.

3- Intelligent Analytics

Extracting value from data requires analysis of the data along different levels. Descriptive analytics allows us to work effectively with more complex data sets than before. Predictive analytics is starting to look at what might be happening given historical trends. This then allows the development of useful models to correlate unrelated variables. They are expected to produce better results through machine learning. Finally, prescriptive analytics then creates more casual models. Since they provide recommendations the focus shifts from analytics to behavior change management. (see figure 4)



Figure 4- Levels of Analytics

Degree of business impact represents the shift from post-mortem analysis to informed future planning based on past experiences. The shift in the basis of decision making from hindsight to insight and foresight could help companies move closer to a business objective.

Complexity of analytics applications refers to the algorithmic sophistication of analytics tools used and characteristics (for example, scale, scope, and frequency) of data sets used.

The shift from descriptive to predictive and prescriptive analytics requires increasingly complex analytics applications (data scientists, large and clean data sets, big data tools); however, the higher degree of business impact should prompt companies to ascend the analytics stack and leverage the copious amount of data to aid decision making and action.

Graphic: Deloitte University Press | DUPress.com

Factors that are driving intelligent analytics components are lower costs of storage for Big Data (see figure 5). Real time improvements in data processing and analysis through the use of advanced streaming technologies like Storm and Spark.





Limitations of intelligent analytics depend on the quality of the data, legacy system limited ability to handle both unstructured and real-time data and the skills in developing models.

Sutardja Center for Entrepreneurship & Technology Technical Report PERFORMANCE METRICS

The types of sensing nodes vary greatly involved and depend on application requirements. These nodes could include a camera system for image monitoring or water/gas flow meters for smart energy. Using RFID/NFC and GPS they can also communicate and register their physical locations in the building and lead to control of the IOT

Local embedded processing is done by microcontrollers/microprocessors which can provide real-time processing which is key requirement of IOT application. Depending on the size of the home requirements could vary from simple network to complex nested sub-networks at different levels. All windows, doors, and electrical equipment have a simple embedded controller that can connect with master MCU for control of entire house. The master MCU, then connects to the internet with clients like security service or other providers allowing homeowner to control all his devices from a portal.

The performance metrics of MCUs for IOT include being energy efficient, quality and reliability, security and breadth of cost effectiveness for different levels of performance and mix of I/O interfaces. First, the MCU must consume low power. For some sensing nodes, they may need to operate on batteries and need to minimize battery replacements. Inside the home the devices must be able to last for years and be reliable in their communication ranges. To guarantee security some layers will need to include encryption as the data is send to the internet. Mass adoption will not be reached until certain price points are reached and these price points will vary based depending on the application requirements.

IOT infrastructure is overloaded word and has many interpretation based on industry, market segment and technology. Most of the large players like AT&T, Samsung, Apple, Google are offering IOT is some form but they are trying to bring more services onto their platforms to make it a platform of a choice. It will evolve slowly as big players learn more about their target markets and customers.

3) Broad Contextual Factors

In recent years companies in IOT have begun to align to help align and resolve different interoperability issues. Alljoyn established by Qualcomm allows devices to discover, connect and communicate directly with other Alljoyn devices across different technologies like Wifi, Ethernet and possibly Bluetooth and ZigBee.

Other companies like Nest and Samsung have aligned have designed Threads to specifically address and overcome some of the limitations found in the connected home. It's a mesh network deigned to

securely and reliably connect hundreds of products around the house without blowing battery life.

The type and amounts of data gathered by billions of devices will create concerns about privacy and confidentiality of the data. Providers of IOT enabled products will need to have a good value proposition for data collected and used and provide transparency into how data is used and protected.

Standard bodies and/or government regulations will need to continue to provide guidance to the IOT ecosystem as different types of applications require them.

Hardware vendors can create more defensible positions by developing unique technology. This could be low-power semiconductors or a new generation of connectivity hardware such as lower-power mesh networks. For IoT component makers, the most obvious candidates for specialization are low-power chipsets, sensors, and communications hardware.

4) Old and New Value Chains

There are many existing solutions in the market, which address home automation. The solution address security, energy consumption, heating/cooling and many more functions in the house. An example which is commonly used is an IoT enabled printer. The printer supplies are visible from any home device (e.g. computer or Cell Phone). One can order supplies (toner) for the printer as they are about to run out. The same solution exists for other printer vendors such as Canon, Samsung, Brother, etc. Some vendors go as far as offer the user an 'Order' button, which forgoes the whole 'search' for the right supplies. Due to the lack of standardization, the current solutions only allow ordering the supplies directly from the vendor and the user doesn't get the best deal available (or ability to order a compatible toner instead of the original).

23

*	Black Cartridge*		
8		100%	
Supply Serial Pages First	ximate Pages Remaining y Level: 1 Number: Printed With This Supply*: Install Date: Used Date:	>6001 Norma1 562824449 13 20100604 20100608	
A	Cyan Cartridge*	100%	
Supply Seria Pages First	ximate Pages Remaining y Level: 1 Number: Printed With This Supply*: Install Date: Used Date:	>6001 Norma1 539362561 8 20100604 20100604	
á.	Magenta Cartridge*	100%	
Supply Serial Pages First	ximate Pages Remaining y Level: Number: Printed With This Supply*: Install Date: Jsed Date:	>6001 Norma1 564266242 8 20100604 20100608	
*	Yellow Cartridge*	100%	Ordering Information Hewlett-Packard supplies can be ordered on the Internet, on-line through your printer software
Supply Serial Pages First	ximate Pages Remaining y Level:) Number: Printed With This Supply*: Install Date: Jsed Date:	>6001 Norma1 537662018 8 20100604 20100608	or by calling an authorized reseller. Refer to your printer User Guide for instructions. Return & Recycling Please return your genuine HP supplies for recycling to Healett-Packard. For more information, please visit us at http://www.hp.com/go/recycle



Two major opportunities in the Internet of Things market standnout for software makers: tackling the challenge to efficiently capture and manage the massive amounts of data that IoT systems generate and focusing on distinctive analytic tools to extract insights from data. Both can have substantial value

for customers. Software that gives executives a simple and clear view of findings in a flood of IoT data will be needed for data-driven decision making. This will require creative design of visualizations and user interfaces. There will also be a need for software that initiates automatic actions based on IoT data. Software players can also implement platform strategies for the Internet of Things. Companies that create platforms—standardized systems that manage devices, collect data, and provide an environment for companies to build custom applications—could have defensible advantages. Once established, platforms become even more powerful due to the investments that customers make in tools and applications that are built on them. Finally, software players that analyze large-scale IoT data sets will be well positioned to create new offerings based on the data. There are a couple of vendors who provide platforms which allow decision making based on data collected via IoT enabled devices. The first is Samsung through their SAMI polatform (https://developer.samsungsami.io/) and the second is AWS throught their IoT offering (https://aws.amazon.com/iot/). Both solutions are are very new and face the similar challenges of on boarding new vendors (e.g. increase supported device pool) and become dominant enough in the market in order to be the new standard (e.g. the SDK of choice). Neither Samsung nor AWS released any financial information about their offering so it is not clear how close they are to profitability. Our educated guess (based on the fact that AWS is in beta stage and Samsung was not referenced by any vendor) is that they are both in the very early stage.

Pricing

AWS pricing is based on messages sent and received by/to the IoT devices. The payment of the service would be by the vendor and not the end user. The End user will not have access to the data. There are no on boarding or costs for the vendor, which is somewhat of a hooking mechanism (no long term commitment, no startup fees). <u>https://aws.amazon.com/iot/pricing/</u> Samsung's SAMI offering doesn't publish any pricing at this point. It does provide an end user portal and a developer portal. The end user portal allows one to connect their supported IoT devices (which currently include all Samsung devices as well as some devices who's vendors created integration

with SAMI). It is not clear yet what pricing model would be chosen in the future.

5) Summarize with Predicted Opportunity

The current IoT for home automation is at very early stage. The growth of the market is expected to triple in the next 5 years (based on number of devices). The current market is very fragmented and there is a lack of interoperability between the different solutions/vendors. The result is suboptimal experience for the end user. As there is no single vendors that provides a complete home automation solution (security system, complete set of appliance, etc.) the user cannot standardise on a single solution and cannot automate end to end workflows (e.g. when leaving the house the security system will turn on, the lights will turn off, etc). We anticipate standards to be drawn and enforced in the very near future in order to improve the end user experience. We also anticipate automated marketplace

solutions to start appearing. We Anticipate that vendors such as Amazon will provide SDKs to allow vendors to create an integration directly from the IoT devices (or a portal) in order to order supplies as they are needed. This will both improve the experience for the end user as well as increase profitability for the vendor.



Figure of anticipated future market place