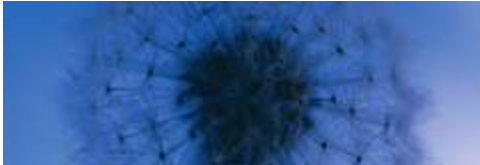




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Prepared for  
**Asia-Pacific Partnership**

AGO Project 5: Cutting Edge Feasibility

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# Executive Summary

Ecoss examined set-top boxes, game consoles, and IP phones because of their high energy savings potential relative to reduced power states. While it is still possible to make improvements in reducing the active-mode power draw, the largest savings potential exists in putting these devices into a low-power sleep state when not in use (Table 1). With few exceptions, products in the three device categories draw almost as much power while idling as they do when fully active. While power scaling often requires no sacrifice to the user experience, sleep modes can involve latency on wake-up, which affects the user experience. What defines an acceptable latency time is typically the culture surrounding energy conservation. Waiting two minutes for the set-top box to fully power up is acceptable to the many European customers who manually turn off their set-top boxes, whereas in the U.S. most consumers demand the set-top box to wake up as fast as the TV: about six seconds. Under current configurations, latency is incurred when powering up to a more functional mode. Ideally, a product would minimize mode-switching latency to increase time spent in a low-power mode.

Today, IPTV set-top box components make it possible to power down to a deep sleep of 0.5 watts. To save energy without degrading the user experience, service providers must increase the amount of time a set-top box spends in deep sleep without it being perceivable to the consumer. Service providers can accomplish this by putting the set-top box into deep sleep when the user is not likely to watch TV, determined by dynamically learning usage patterns or triggered by an “away” setting pressed on a home security panel. When the user is home, the set-top box could return to a light sleep, allowing it to wake faster than the TV, yet still using 40 percent less power than fully on. As early as Q3 2011, one primary set-top box server and multiple thin-clients can replace a network of redundant complex set-top boxes. Increased savings may come from newer TVs that offer built-in client functionality.

As game consoles increase functionality, they spend as much time playing movies and music as they do playing games. If game consoles were to scale power to functionality, the power required to listen to music and play movies would be greatly reduced. A second opportunity for saving energy involves putting game consoles to sleep when left idle for a defined period. To do so requires collaboration between the hardware and software developers. Mobile gaming platforms already employ this technology because energy efficiency is important for extending battery life.

Many IP phones use almost the same amount of power when idle versus in use. Power over Ethernet power management presents a way to turn the phones off after business hours, however it is not widely implemented because phones lose the ability to immediately make or receive after-hour phone calls, including emergency calls. Proxying and Energy Efficient Ethernet are two technologies that can reduce idle-mode power. Assuming low wake-up latency, manufacturers could implement a proxy for phones on a SIP network. If the switch and IP phone support Energy Efficient Ethernet, the network interface sleeps when there is no data traffic, further reducing power draw.

**Table 1: Cutting Edge Technologies by Category**

Set-Top Boxes	Game Consoles	IP Phones
<b>Multi-room architecture</b>	Power scaling	Proxying
<b>Decrease light sleep and on-mode power draw</b>	User-friendly Auto-Power Down	Energy Efficient Ethernet
<b>Increase time spent in deep sleep</b>		

# 1. Methodology

To explore each product category, Ecos used a mix of academic articles, academic interviews, component vendor interviews, industry reports, industry analyst interviews, manufacturer interviews, previous Ecos work, product websites, and service provider interviews. At the request of our partners, Ecos has withheld company names and contact information. For this report, Ecos has compiled the following table with regards to the statement of work.

**Table 2: Statement of Work Accomplishments**

Task	Status
<b>Conduct a literature review and telephone outreach</b>	Ecos has interviewed ten industry experts and reviewed company whitepapers, industry reports, and academic studies since 2008.
<b>Obtain samples of functioning prototypes or components</b>	No prototypes were available within the timeframe for this document. Ecos received manufacturer test data for 802.3az IP phones, and reviewed E3 game console releases.
<b>Obtain data from the supplier about the measured energy use in various modes and test these devices in the laboratory to verify the claims</b>	Ecos has documented IP phone measurements from various manufacturers, tested multiple game consoles and set-top boxes

## 2. Findings

### 2.1. Set-top Boxes

When it comes to TV entertainment, consumers wish to see what they want, when they want, how they want. To see what they want, many consumers sign up for a pay-TV subscription, since service providers have exclusive access to a wide range of high demand programming such as popular series and sports packages. The service provider supplies the subscriber with a set-top box (STB), which is used to deliver television signals. A simple STB has a one-way radio, meaning it can only receive signals from the head end, which is where the signal originates. A complex set-top box includes a return path, allowing for an interactive program guide and on-demand programming. Both simple and complex STBs come in standard definition (SD) and high definition (HD) varieties, which define the maximum resolution a STB can display. As widescreen TVs became the norm in the mid 2000s, service providers began to replace SD STBs with HD ones, which offer screen resolutions up to 1920x1080 pixels, termed 1080p.

To address when consumers watch content, service providers offer an on-demand library of stored content, which requires a two-way communication capability in the STB.<sup>1</sup>This service is known as video on demand (VOD). Additionally, service providers offer digital video recorders (DVRs), which are STBs that can store content and timeshift, or pause and replay, live TV. This added functionality requires a hard drive and an additional TV tuner so the consumer can view and record discrete channels simultaneously.

Pay TV service providers are offering the ability to watch programming by other means than the STB in order to compete with over-the-top services such as Netflix, YouTube, and Hulu, which can stream video content to TVs, game consoles, Computers, Tablets, and cell phones. Some service providers have begun to offer pay-TV content to tablets, although the market is slow to shift, primarily due to content protection concerns. One such example is Dish Network's incorporation of a Slingbox (an over-the-top streaming device) into the STB, making it possible to login to a STB and watch DVR and live content from any internet connection with a compatible viewing device.

#### Background Information

The STB market for pay-TV is unique because consumers do not own the equipment nor do they make the purchase decision. The service provider owns the equipment and decides what equipment to purchase. The largest service providers, such as DIRECTV and Comcast in the U.S., have the purchasing power to decide what hardware and software the manufacturers and component vendors install in the STB. Therefore, while it may be helpful to make the end consumer aware of the energy consumption of STBs, they have no say in the energy efficiency of the STB installed in their home. Likewise, component vendors and manufacturers may build a STB with aggressive power saving features; however, the service provider may disable these features to maximize convenience at the cost of the customer's energy bill. For example, if all STBs are on and ready to receive a software update, the service provider only needs to send the update once, instead of continually broadcasting the update until each STB has turned on and downloaded it. Therefore, the most effective means of intervention for STBs is to engage with the service providers. While it is technically possible to require service providers to reimburse customers for the energy consumed by STBs, regulators have been unsuccessful in implementing this strategy for the better part of a decade.

Free-to-air (FTA) STBs offer the same provisions as a simple pay-TV STB except they do not require a conditional access module to secure the content, because the content is free. Since FTA boxes are

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<sup>1</sup>For satellite services, outgoing communication typically requires an internal or external internet modem because satellite dishes are not designed to send requests to the satellite.

classified as simple STBs, they fall under European Commission Regulation 107-2009, which states that they must auto-power down to .5W when not in use. Digital HD-ready TVs have FTA functionality built-in, limiting the FTA STB market to older TVs and TVs where users desire a digital video recorder (DVR). FTA DVRs will be included Regulation 107-2009 in 2012 (Table 3).

**Table 3: 2012 Power Limits for European Commission Regulation 107-2009**

	Standby mode	Active mode
<b>Simple STB</b>	0.50 W	5.00 W
<b>Allowance for display function in standby</b>	+ 0.50 W	—
<b>Allowance for hard disk</b>	—	+ 6.00 W
<b>Allowance for second tuner</b>	—	+ 1.00 W
<b>Allowance for decoding HD signals</b>	—	+ 1.00 W

Source: European Commission

The European Code of Conduct version 8, European Industry Voluntary Agreement, and ENERGY STAR are all voluntary forms of increasing the energy efficiency of STBs (Table 4). The European Industry Voluntary Agreement, which is a form of self-regulation in lieu of mandatory regulation, represents 75 percent of the subscriber base stating that 90 percent of employed STBs must meet the requirement (Figure 1).

**Table 4: Comparison of International Voluntary Agreements (kWh/year)**

BASE FUNCTIONALITY	ENERGY STAR Version 2.0 (effective January 2009)	EU Code of Conduct v8 (effective January 1, 2010)	EU Voluntary Agreement (Tier 1 effective June 1, 2010)	ENERGY STAR 3.0 (effective September 1, 2011)	ENERGY STAR 4.0 (effective July 1, 2013)
<b>Cable</b>	70	60	45	60	45
<b>Satellite</b>	88	60	45	70	50
<b>IP</b>	45	40	40	50	25
<b>Terrestrial</b>	27	47	40	22	18
<b>Thin Client</b>	27	40	40	35	20
ADDITIONAL FUNCTIONALITY					
<b>Additional Tuners / Multi-stream</b>	14 to 53	6	20	8 to 16	6 to 8
<b>Advanced Video Processing</b>	18	18	20	12	8
<b>DVR</b>	60	32	20	45	36
<b>High Definition</b>	35	-	20	25	16
<b>Multi-room</b>	44	18	38	40	30
<b>Return Path / DOCSIS</b>	20	53	60	20	15

Figure 1: Industry Voluntary Agreement Signatories

Set Top Box		Chipset	Service Providers		Middleware	Conditional Access
						
						
						
						
						
						
						

Source: Digital Interoperability Forum

To gauge future effectiveness of the voluntary agreements, Ecos analyzed the cutting edge components that will be offered in upcoming STBs. For example, a new Broadcom SOC states that it, “integrates power management controllers and regulators, supports Energy Star® and European Code of Conduct set-top box requirements, and offers flexible and configurable standby and active modes of operation.”

### Cutting Edge Technology

To reduce household STB energy consumption, manufacturers can do four things: reduce the number of complex STBs in the house, reduce on-mode power, reduce sleep mode power, and increase the time the STB is in deep sleep.

### Client/Server Multi-room Networks

Currently, each TV that is able to watch pay-tv and video on demand requires a complex STB. Some STBs, such as those by EchoStar, can serve two TVs per STB, although cable length becomes an issue. By using networking protocols, such as MoCA or HomePNA, STBs can communicate with one another inside the home through coaxial cable or phone line. Networking STBs together makes it possible to reduce the number of required DVRs per house because each auxiliary STB can share the DVR in the main STB. By integrating other functionalities, such as tuners and content security, into the primary DVR, it is possible to reduce redundant functionality and save energy at the household level.

RVU is a promising remote user interface (RUI) technology that eliminates the need for more than one complex STB per household. RVU was founded by Broadcom, Cisco, DIRECTV, Samsung, and Verizon, and functions by having the primary STB act as a server, which distributes content to clients throughout the home. In the near future, these clients may be approximately 8-watt thin client STBs that convert the video signal from a coaxial cable to a video output cable (e.g. MoCA to HDMI). If TV manufacturers rapidly adopt RVU, TVs will feature built-in RVU clients, further increasing energy efficiency. In the near term, a prototype RVU server STB would include six tuners (each of which can automatically power down when not in use) and a hard drive for recording content. To watch TV in another room, the server tunes in the desired channel and the signal is sent through coax, where the client converts the signal to a video format and displays the content on screen. Figure 2 depicts an example network using RVU.

Figure 2: Example of an RVU Networked Multi-room Solution



Source: EPA

Another possibility for multi-room architecture is a media gateway, which integrates the functionality of a STB, modem, router, and analog telephone adapter. Examples include the ARRIS media gateway, primarily for the U.S. market, and the UPC Horizon Connected Home Gateway, which is scheduled to be deployed across Europe in 2012. These are attractive offerings to small triple-play (TV, internet, voice) service providers because they reduce capital expenditure. Larger service providers may not rapidly adopt this technology because it requires a large turnover in stock. These media gateways include DVR functionality that can serve multiple thin clients, minimizing the number of networking devices required in the home as well as simplifying how content is shared across devices (Figure 3). While Ecos could not beta test these products, industry experts estimate the gateways will consume 30 – 50 watts.

Figure 3: ARRIS Media Gateway



Source: ARRIS

### Reducing On-Mode Power

Reducing the on-mode power requires a closer look at the functional components in a STB. At the core functionality, a STB receives a television signal and displays it on a TV. Under this definition, the Apple TV 2 functions extremely efficiently, operating at approximately 2 watts. Without conditional access or a



DVR, the Apple TV 2 performs a function similar to a FTA STB. While it may not be technically possible to achieve a power draw as low as an Apple TV 2, stakeholder communication suggests it does set a core benchmark for which to aim. For STBs with conditional access, DIRECTV's latest HD STB shows a power reduction up to 30 percent over the prior generation, using 10.7 watts in on-mode.

Including efficient channel tuners is a second method to reduce on-mode power draw. A complex STB has two types of tuners: in-band tuners for broadcast TV channels and out-of-band tuners for data and video on demand. Before tuners and demodulators were integrated, a single-channel tuner and demodulator used 1 watt each. New efficient chips support eight data channels on a single chip that uses 1.3 watts. A separate chip supports two TV channels, which uses 0.8 watts fully utilized and scales down to 0.4 watts for a single channel. Therefore, a new STB server could support six TV channels and eight data channels by using only four chips that scale power to functionality.

Eliminating the need for a hard drive in the STB is a third method to reduce on-mode power draw. As previously mentioned, multi-room architectures eliminate the need for more than one DVR per household. With a fast internet connection, it is possible for service providers to relocate DVR storage to the "cloud," obviating the need for a traditional DVR in the home. Cablevision, one of the largest pay-tv service providers in the U.S., has reportedly stopped purchasing traditional DVRs for installation on consumer premises. Instead, they will be providing customers with a remote-storage DVR (RS-DVR) located in their servers.<sup>2</sup> Cablevision chose this path because RS-DVRs are cheaper to purchase and maintain than standard DVRs. However, U.S. courts mandate that Cablevision must store an individual copy of a show for each user. For example, if 10,000 users recorded *The Office* season finale, then 10,000 unique copies must exist on the Cablevision servers.<sup>3</sup> This requirement is only a small concession for the prosecuting content owners in the case. Therefore, it may be possible to lobby with the service providers to reduce the number of redundant copies, thus increasing data center efficiency. Regardless of the redundant copies and server space used to back up the information, this may still be a win for energy efficiency. Best in class datacenter servers use extremely efficient power supplies, can spin down hard drives when not in use, and are efficiently cooled. Additionally, because the service provider is paying the energy bill for the RS-DVR, they will generally make the server as efficient as makes fiscal sense. For example, a metered storage server used 1 watt for every 120 GB of useable capacity (Baliga, et al. 2008). Running constantly, that 120 GB space would consume 9kWh/year, compared to the ENERGY STAR v3.0 allowance of 45kWh/year for a DVR-enabled STB.<sup>4</sup> Alternatives to RS-DVRs include replacing standard 3.5" DVR hard drives with smaller 2.5" drives or flash drives. However, these products are generally not cost effective from an energy savings standpoint.

### Reduce Sleep-mode Power

Server STBs for multi-room architectures can support eight data channels. For cable applications, the transport protocol is typically DOCSIS, the same protocol that is used in cable modems. Market analysts forecast that DOCSIS 3.0 modems, which have a higher throughput and use more power than DOCSIS 2.0 modems, will gain majority market share in the coming years. As higher throughput is required for STBs, Ecos expects DOCSIS 3.0 to begin to take the majority of the STB market as well. Internet gateways, which require a battery backup for emergency VoIP calls, have a built-in low-power battery backup mode to reduce the battery cost to the service provider. This mode reduces the DOCSIS system power draw to 2 watts with a latency of about one second. As STBs shift towards media gateways with

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<sup>2</sup> While similar services exist internationally, this is the first of its kind to offer recording more than free-to-air content.

<sup>3</sup> Content owners lobbied against the technology, arguing it allows the service providers to store libraries full of content without paying a leasing fee.

<sup>4</sup> Ecos assumes there are no redundant data centers RS-DVRs. Ecos also assumes energy use from data transmission is negligible because current network infrastructures do not scale power to utilization via 802.3az EEE.

built-in DOCSIS modems, powering down to the battery backup mode presents an opportunity to reduce the sleep-mode without incurring a large latency.

### Increase time in Deep Sleep

Among the most efficient IPTV solutions, one U.S. IPTV STB manufacturer uses Broadcom's BCM7231 system-on-chip (SOC), featuring a power management microprocessor.<sup>5</sup> This SOC allows the device to auto-power down to a deep sleep of 0.5 watts, functioning very similarly to a network connection proxy for IP edge devices. For instance, if the user wanted to record a TV program remotely, she could setup the recording from her cell phone and the microprocessor would wake the DVR from deep sleep to start recording. Because the STB maintains constant connectivity with the network, it can power components down when not needed. The problem is the wake-up latency. While the hardware can boot in ten seconds, current middleware solutions take 3-5 minutes until they can fully function. In Europe, where it is common to turn off the STB manually, this latency is acceptable. However, in the U.S., service providers strive for STBs to start up as fast as TVs: about six seconds. Some U.S. service providers also elect using a light sleep instead of deep sleep to provide additional functionality to users. For example, occasionally the remote that controls the STB and TV can fall out of sync and put the STB to light sleep while the TV remains on. If this happens the STB can still process SD video without audio and will show a screen saver and a window offering to resynchronize the controller. This feature reduces calls to the help desk and provides added brand marketing by displaying the company logo in the screen saver.

Satellite TV poses the same latency challenge. When the STB goes into a deep sleep, it loses contact with the satellite. Depending on weather, it can take up to five minutes to discover the satellite and reconnect. Therefore, the goal is to minimize wake time when the user wants to watch TV and maximize energy consumption when the user is away. To do this, the STB can "learn" the user's schedule. For example, if the STB is typically in sleep-mode when the user is at work, there is a high probability the STB could go into deep sleep during that time and revert back when the user typically returns without impacting perceived quality of service (QoS). While promising in theory, energy savings are largely dependent on the QoS threshold. For example, if the STB learns there is a 50 percent probability the user may turn the TV on at 2:00pm on a Monday, will it stay in deep sleep? Unfortunately, this concept is too new to be framed in a prototype available for Ecos to test. It is worth noting that some service providers have received negative customer feedback from similar programs because it is seen as an invasion of privacy.

Cable companies may begin to offer a similar user-friendly APD patterns, although the solution will not be available in the near future. As multiple service operators (MSOs) begin to offer home security solutions, it is possible for device states to be determined by home presence. For example, if a user sets the security system to "away" before leaving, the STB could power down into a deep sleep until the user returns and disarms the alarm. This is a simple yet effective solution for many home network devices, although prototypes are not yet available to estimate energy savings.

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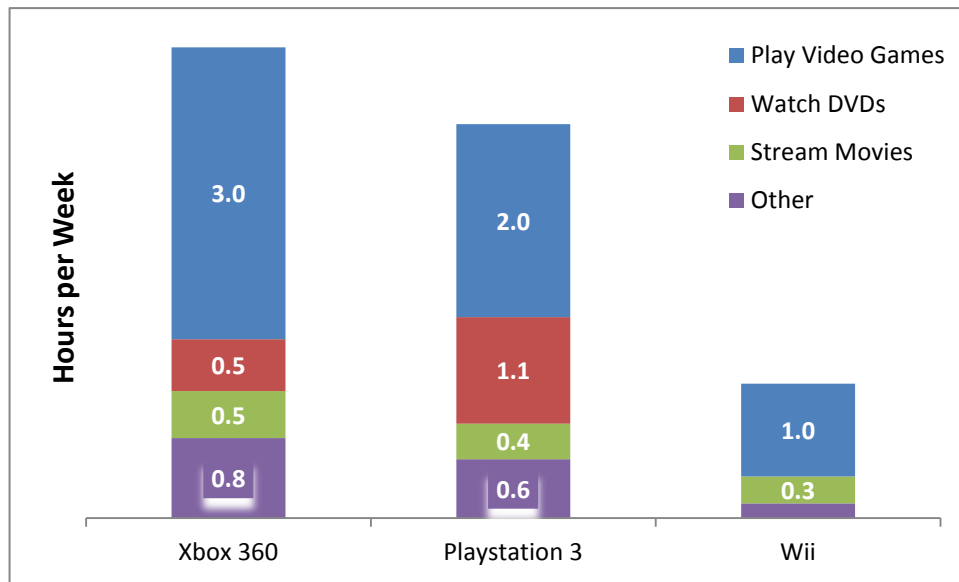
<sup>5</sup> IPTV can refer to telco IPTV, where TV service is delivered through a telco provider, such as AT&T U-Verse in the U.S., or it can alternatively refer to over-the-top (OTT) content subscriptions, such as Hulu Plus and Netflix. Ecos uses the former definition when referring to IPTV.

## 2.2. Game Consoles

### Background Information

Game consoles are computers designed to play computationally intensive games. The experience is differentiated from a PC as consoles allow for local multiplayer gaming, use a controller as an input, and use a TV as an output. The latest generation of game consoles also serves as a home theater PC, providing the user with a hard drive, DVD player, OTT video streaming, and ability to network to a computer to access photos, movies, music, and more. Figure 4 shows nearly 40 percent of the time the Xbox 360 is on, it is spent on non-gaming tasks. Likely because of the blu-ray functionality, this goes up to almost 50 percent for the PS3. Even the Wii, which lacks DVD or blu-ray capability, shows 25 percent of time spent on non-gaming tasks.

Figure 4: Weekly Game Console Usage by Task<sup>6</sup>



Source: Nielsen

### Reducing On-Mode Power

Game console power levels, while low compared to gaming PC power levels, reflect the focused attention to on-mode power levels of design teams that are motivated by market forces to improve product reliability and to reduce fan noise and console size. Inefficiency leads to heat output, which results in a higher bill of materials (more fans, bigger power supply) and higher cost to replace consoles under warranty, as was the case with the first revision of the Xbox 360 and PS3.

A gaming PC uses considerably less power when idle compared to playing a game because its dedicated hardware (e.g. graphics card) can effectively scale power. Under their current configuration, game consoles use a large amount of power while idling (Table 5). The difference between modes was greater in previous game console revisions; however, die-shrinking has reduced power consumption of each mode, thus reducing the difference between modes as well. From this data, power scaling does not appear to have been a design priority in the current generation of game consoles. An efficient game

<sup>6</sup> The Wii is used more for gaming because it is a social gaming device and is played about three times less than the other two consoles. The PS3 spends more time watching movies because it fulfills the role of a standalone blu-ray player and at one time was one of the least expensive blu-ray players on the market.

console would play a DVD using the same amount of power as a DVD player— about 10 watts. However, to accomplish this would require new, dedicated circuitry specifically for playing DVDs, adding to the bill of materials (ESA 2009).

**Table 5: Game Console Power Draw for Varying Tasks (watts)**

Task	PS3	Xbox 360	Wii	Gaming PC
<b>Active Gameplay</b>	85	103	11	143
<b>Netflix streaming</b>	73	72	11	94
<b>Idle</b>	73	80	10	57
<b>Standby</b>	0.5	0.6	0.9	0.2

Source: Ecos

### Increasing Time in Deep Sleep

Increasing time spent in deep sleep by auto-powering down idle systems presents the largest opportunity for game consoles. The price of deep sleep is reduced quality of service (QoS). Game consoles boot up to the main menu in about twenty seconds, which is likely acceptable to a majority of users. Therefore, if a console left idle at the main menu powers itself down after an hour, perceived QoS may not decrease. However, powering down a paused game, which could take the user hours to return to the paused game state, would greatly reduce QoS. To maintain a minimum QoS in this scenario, the console must be able to save game state information before auto-powering down so the console awakes to the proper place in the game. This is no simple task; for released consoles, it would require software developers make certain changes. For new systems, console manufacturers would play the key role is creating power management protocols. If done poorly, saving the game state invites the possibility of hackers and arguably reduces excitement and quality of game play (ESA 2009). In the case of games played online, Ecos believes the inherently dynamic nature discourages idling. In many cases, the game sends the user to a main menu after a set duration, where APD could then take effect.

### iPad 2

Just as the majority of desktop users are shifting time spent towards notebooks, there is growing evidence that more game play may shift towards mobile platforms. For example, the iPad 2 has the processing ability to power two screens: its native 1024x768 screen and a full HD TV in 1080P at thirty frames per second.<sup>7</sup> While gaming controllers and popular game titles may not yet be available for tablets, games such as *Real Racing 2 HD* demonstrates the dual-processor, battery powered iPad 2 can process extremely computationally intensive HD games and display them on the home TV (Nelson 2011). Epic Games, the creator of the game engine, released a development kit for the iPad 2 to invite more HD game developers to the tablet platform. This trend is sure to increase as tablets continually offer increased functionality over incumbent consoles, such as gyroscopes, accelerometers, secondary screens, GPSs, and mobility.

Because designers build these games with mobility in mind, many games have the ability to save game state at any time. Ecos tested this by putting the iPad 2 into standby while in the middle of a level of *Infinity Blade*, a computationally intensive game. After thirty minutes of inactivity, we reactivated the tablet and the game returned to the same state instantly. After leaving the tablet idle for over two hours, the game application had exited, yet returned to the same point in the game after startup with no noticeable

<sup>7</sup> While mobile platforms like the Nintendo 3DS are appealing, they offer little for the at-home gamer because of the stylus interface and small screens (800x240 and 320x240 for top and bottom screen, respectively).

latency. The technology demonstrates that it is possible for games to go into a low power state without loss of QoS, if the operating state and developer requirements are unified towards saving and restoring from a variable point of play. When fully charged and connected to a charger, the iPad2 draws approximately 5 watts when playing a game and idles at 3 watts. While it is not a direct substitute for the high-end graphics processors in game consoles, it is an impressive example of how efficient a device can be when energy efficiency is a primary consideration.

### **Joint Console-STB**

Although the U.S. has yet to see a STB that offers gaming functionality, Broadcom showcased its BCM7231, the same SOC that offers a deep sleep IPTV solution, at two conferences in March 2011 (Broadcom 2011). The chip features Bluetooth 2.0 compatibility with 3DiJoy's motion gaming platform, offering a Wii-like experience without the game console. While the concept may not gain traction where the Wii already exists, it could do very well in China, where the government banned the sale of game consoles. Gaming aside, the SOC ushers in the possibility for a motion-sensitive remote controller to navigate through TV menus, similar to controlling a mouse cursor on a computer. As this relates to energy consumption, it may increase the amount of time spent in front of the TV, but positively integrates the 11-watt Wii functionality.

More recently, at the E3 Game Expo in June, Microsoft announced that the Xbox 360 will be able to stream live TV in fall 2011. By replacing the TV remote with voice recognition, along with a Bing powered engine, Microsoft is giving users "a reason to turn on the Xbox every day" (Gross 2011). Subscription details are still unreleased, leaving it too early to speculate whether the new feature could effectively replace standard STBs in homes.

### **Wii U**

At E3, Nintendo announced that their upcoming game console, the Wii U, will be released in 2012. The controller for the console is a tablet-sized screen with the addition of tactile buttons (Figure 5). The optical drive is not blu-ray compatible, which means duty cycle will likely remain low because it will not be used as a blu-ray DVD player. Based on the limited knowledge of included hardware, Ecos estimates the console may use slightly less power than the PS3, although more accurate projections must wait until it is released.

**Figure 5: Upcoming Nintendo Wii U**



*Source: Nintendo*

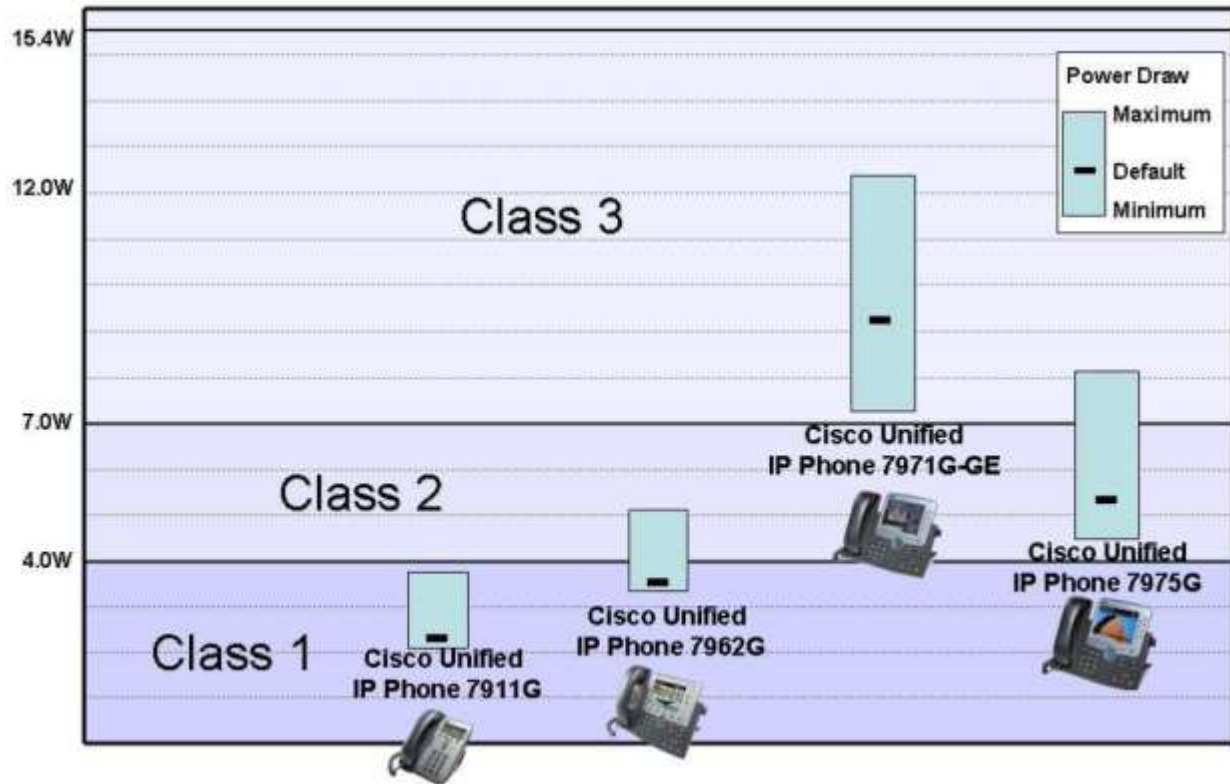
## 2.3. IP Phones

IP phones send voice over an IP network instead of the traditional analog public switched telephone network (PSTN), offering a variety of advantages. They require constant network connectivity and exist in many different variations. For example, a softphone, such as Skype or Google Voice, is simply a software application, where the host is the computer. Devices such as the MagicJack in North America connect a standard phone to a computer via a USB dongle. These devices disallow older computers without Wake-on-VoIP from going to sleep in order to receive incoming calls, increasing the energy consumption of the PC. An analog telephone adapter (ATA) connects directly to the router or modem, allowing standard phones to work over an IP network. Other ATAs, such as the Vonage home phone system, feature a custom phone and charging station that connect to the router. Despite these solutions, the residential market penetration for IP phones is still much smaller than the commercial market, where the majority of businesses use IP office phones. Therefore, Ecos focuses primarily on IP office phones when discussing proxying and Energy Efficient Ethernet.

### Background Information

The IP phone market, like the markets for all other IP edge devices, is rapidly changing with advances in networking technologies. To explain the current market landscape, Ecos refers to a power consumption study Cisco performed in 2008 (Figure 6). The large power delta between minimum and maximum is due to components including screen, speakerphone, and Ethernet port. Phones from other manufacturers have similar power draws, relative to phone features. To measure residential IP phones, Ecos tested a Vonage home phone system. The power draw was comparable to office phones, at approximately 4.7 watts using an external power supply. Additionally, the phone scaled power up 1.4 watts when the phone produced a dial tone, although there was no power delta between a phone ready to make a call and a phone on a call.

Figure 6: Power Draw of different Cisco IP Phones

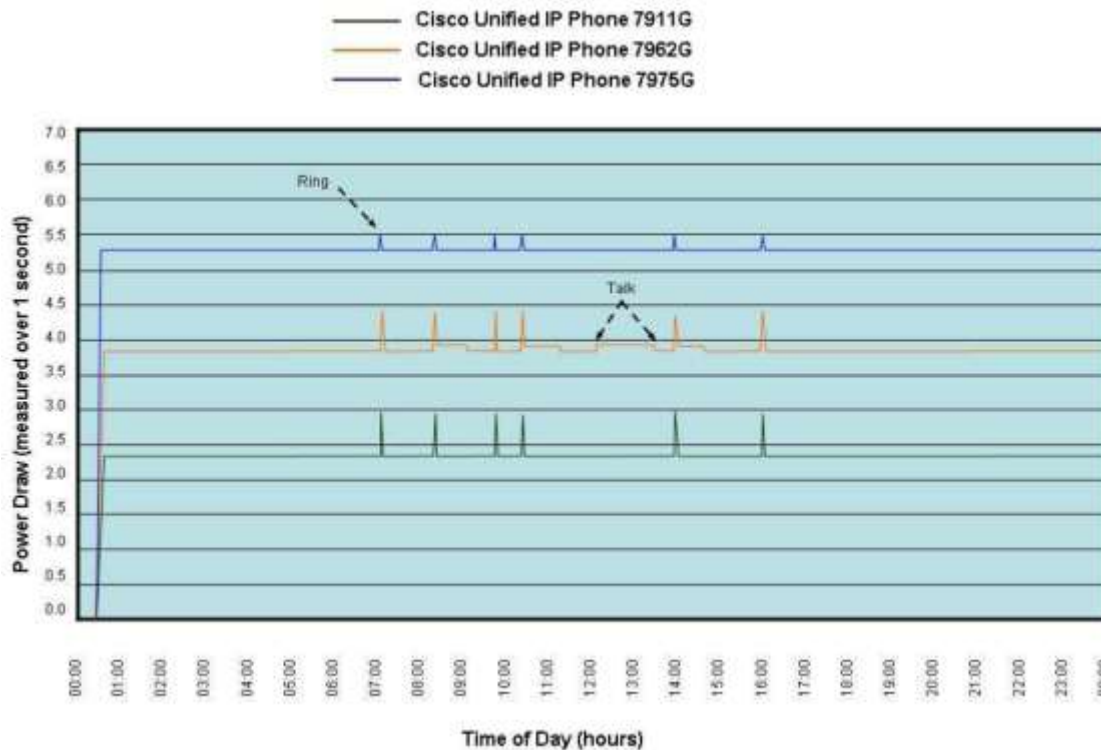


Source: Cisco

Many IP office phones can receive power over the same cable that connects them to the network; this capability is called Power over Ethernet (PoE). Although not as efficient as a new external power supply, PoE is generally preferred in the workplace because it allows for networked power management, eliminates the need for an outlet and power cord, and allows for emergency calls during power outages because the switch typically employs a universal power supply.

Similar to STBs, IP phones present an opportunity to save power by reducing power when not in use, which is most of the time (Figure 7). As the figure shows, there is only a small power delta between when the phone is in use versus idling for these particular models.

Figure 7: Cisco Metered IP Phone Power Draw



Source: Cisco

### VoIP Proxy

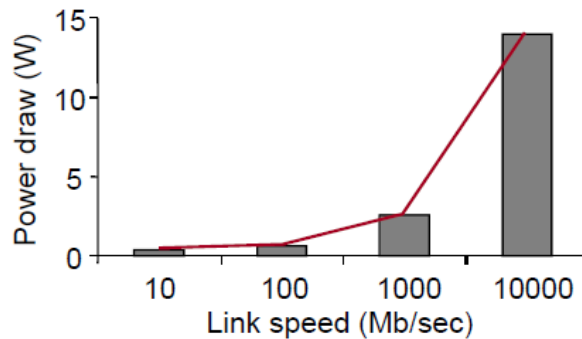
A proxy is an “entity that maintains network presence for a sleeping higher-power host” (Ecma 2010). The technology only requires the compliance of one device, such as an IP phone, which is useful because it allows the phone to go to sleep without losing network connectivity and without requiring other devices to be compliant. If correctly implemented, the ECMA-393 ProxZzzy standard could be used on the phone, allowing the phone to go into a sleep-mode without the network knowing the phone is in sleep-mode. This is useful because then the network is not required to act differently depending on the state of the phone. The chief concern is latency. Whereas a two-second wake time for a computer or STB is perfectly acceptable, an IP phone must wake in less than 250 milliseconds before it impacts QoS (Cisco 2008). These proxies apply to phone networks using Session Initiation Protocol (SIP) signaling. While SIP is a widely accepted signaling technology with an expanding installed base, many legacy systems use other methods. In the residential sector, most cable E-MTAs (gateways integrating modems and ATAs) currently use MGCP, although a migration to SIP is expected in the coming years.

### Energy Efficient Ethernet

A typical IP phone has multiple built-in interfaces to work with older devices. For example, a typical IP phone might have “10/100/1000Mbps” functionality, meaning it can work with a legacy PC that only supports a 10Mb/s transfer rate, up to a new PC that supports a 1000Mb/s rate. Once the networked devices negotiate the top speed, they only use that interface, regardless of the data flow. This poses a particular problem as high-end IP phones offer high-powered gigabit interfaces (Figure 8). Although voice data requires less than a 10Mbps throughput, many IP phone manufacturers are implementing 1000Mbps ports. This is because companies commonly connect computers to the IP phone, which then connects to the network. In consolidating computer and phone data traffic, fewer ports are required at the switch, at the expense of a higher throughput Ethernet interface.



**Figure 8: The Correlation between Port Capacity and Port Power<sup>8</sup>**



Source: Christensen

To mitigate this growing energy concern, two options have been presented. The first is to change interfaces based on the amount of data, called adaptive link rate scaling. This technology has been used in laptops to save energy (and thus extend battery life) when connected to Ethernet. However, there is a noticeable latency of about two seconds when switching between interfaces. The alternative is to use the fastest negotiated interface and put it to sleep when it is not transferring data. The latter concept is preferred because it saves approximately the same amount of energy as the former while incurring only a three microsecond latency (Bolla, et al. 2010). In September 2010, the concept was ratified as IEEE protocol 802.3az, Energy Efficient Ethernet. When traffic comes in, such as a phone call, the device wakes up to the fastest interface to transfer the data, then goes back to sleep. One phone manufacturer reported that 802.3az-compliant Ethernet ports scale power from 380 to 105mW when idle, therefore a 2-port phone would idle 0.5 watts lower. The downside to EEE is that both the IP phone and networking device need to have the technology enabled to function, making rapid adoption for both networking and edge devices critical.

## Next Steps

For each product category, it is critical to bring cutting-edge energy efficient technologies to market saturation as quickly as possible. The strategy to saturate each market varies between STBs, game consoles, and IP phones. For STBs, Europe has shown that a self-regulating Industry Voluntary Agreement is a successful approach to decrease STB energy consumption without stifling innovation. For game consoles, where the current generation has three products, a voluntary program such as ENERGY STAR may not be suitable because of the limited product selection and long lifecycle. Instead, direct engagement with manufacturers to discuss how to incorporate energy-saving opportunities may be the best approach. For IP phones, reducing energy consumption when idle is largely dependent on the underlying network infrastructure. Therefore, as newer SIP-based networks emerge, functioning proxy technologies should be ready for implementation across product offerings.

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<sup>8</sup>For illustrative purposes only. The measurements taken for this graph are from a networking device, not an IP phone. Currently, no IP phones use 10Gb/s interfaces.

## Definitions

### Set-top Box Base Type

**Cable.** A set-top box whose primary function is to receive television signals from a broadband hybrid fiber/coaxial or community cable distribution system with conditional access (CA) and deliver them to a consumer display, thin-client/remote set-top box and/or recording device (U.S. EPA 2011b).

**Satellite.** A set-top box whose primary function is to receive television signals from satellites and deliver them to a consumer display, thin-client/remote set-top box and/or recording device (U.S. EPA 2011b).

**Cable Digital Transport Adapter (DTA).** A minimally-configured set-top box whose primary function is to receive television signals from a broadband. Hybrid fiber/coaxial. or community cable distribution system and deliver them to a consumer display and/or recording device (U.S. EPA 2011b).

**Internet Protocol (IP).** A set-top box whose primary function is to receive television/video signals encapsulated in IP packets and deliver them to a consumer display, thin-client/remote set-top box and/or recording device (U.S. EPA 2011b).

**Terrestrial.** A set-top box whose primary function is to receive television signals over the air (OTA) or via community cable distribution system without conditional access (CCA) and deliver them to a consumer display, thin-client/remote set-top box and/or recording device (U.S. EPA 2011b) .

**Thin-client / Remote.** A set-top box that (1) is designed to interface between a Multi-room set-top box and a TV (or other output device); (2) has no ability to directly interface with a Service Provider; and (3) relies solely on a multi-room set-top box for content. Any set-top box that meets the definition of a cable Satellite, IP or terrestrial STTB is not a thin-client/remote set-top box(U.S. EPA 2011b).

### Set-top Box Product Features

**Base Functionality.** The primary functionality that defines the ENERGY STAR criteria applicable to a particular set-top box. Base Functionality is one of the following: Cable, Satellite, IP, Terrestrial or Thin-Client/Remote (U.S. EPA 2011b).

**Advanced Video Processing.** The capability to encode, decode and/or transcode audio/video signals in accordance with standards H.264/MPE G 4 or SMPTE 421M (U.S. EPA 2011b).

**CableCARD.** The capability to decrypt premium audio/video content and services and provide other network control functions via a plug-in conditional access module that complies with the ANSI/SCTE 28 HOST-PPOD Interface Standard (U.S. EPA 2011b).<sup>9</sup>

**Digital Video Recorder (DVR).** The capability to store video in a digital format to a rewritable disk drive or other non-volatile storage device integrated into a set-top box. This definition excludes video capture software for personal computers or server-based DVR capabilities (U.S. EPA 2011b).

**Data Over Cable Service Interface Specification (DOCSIS®).** The capability to distribute data and audio/video content over cable television infrastructure in accordance with the CableLabs® Data Over Cable Service Interface Specification (U.S. EPA 2011b).<sup>10</sup>

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<sup>9</sup><http://www.scte.org/standards/>

<sup>10</sup><http://www.cablelabs.com/specifications/>

**European Data Over Cable Service Interface Specification (EuroDOCSIS).** An international suite of standards that define interface requirements for cable modems involved in high-speed data and video/audio content distribution over cable television systems.

**High Definition (HD) Resolution.** The capability to transmit or display video signals with resolution greater than or equal to 720p (U.S. EPA 2011b).

**Home Network Interface.** The capability to interface with external devices over a high bandwidth network (e.g. IEEE 802.11 (Wi-Fi). MoCA. HPNA). For purposes of this specification IEEE 802.3 wired Ethernet is not considered a Home Network Interface (U.S. EPA 2011b).

**Middleware.** Middleware is similar to an operating system in a computer although the customer does not see it. It can communicate between the service provider head-end and network equipment. What the customer does see is the service provider applications software such as a channel guide and video on demand. Several cable operators have adopted tru2way/OCAP specifications as the standard for their middleware. IPTV stakeholders on the other hand have yet to come to a clear consensus on any standardized middleware platform.

**Multi-room.** The capability to provide independent audio/video content to multiple devices within a single-family dwelling. This definition does not include the capability to manage gateway services for multi-subscriber scenarios (U.S. EPA 2011b).

**Multi-stream.** The capability to deliver two or more simultaneous audio/video streams to a consumer display, thin-client/remote set-top box or recording device. The simultaneous streams may be delivered via a physically separate input or via the primary input. This definition does not include out-of-band tuners (U.S. EPA 2011b).

**Removable Media Player.** The capability to decode digitized audio/video signals on DVD or blu-ray Disc optical media (U.S. EPA 2011b).

**Removable Media Player / Recorder.** The capability to decode and record digitized audio/video signals on DVD or blu-ray Disc optical media (U.S. EPA 2011b).

## Operational Modes

**On- Mode.** Where the product is connected to a mains power source, has been activated and may be providing one or more primary functions. The common terms “active” “in-use” and “normal operation” also describe this mode (U.S. EPA 2011b).

**Sleep-Mode.** Where the product is connected to a mains power source, is not providing a primary function and offers one or more of the following user oriented or protective functions which may persist for an indefinite time (U.S. EPA 2011b):

- 1) To facilitate the activation of other modes (including activation or deactivation of On mode) by remote switch (including remote control).internal sensor. timer;
- 2) Continuous function: information or status displays including clocks;
- 3) Continuous function: sensor-based functions.

**Deep Sleep State.** A power state within Sleep Mode characterized by reduced power consumption and increased time required to return to full On Mode functionality (U.S. EPA 2011b).

## Other Definitions

**Auto-Power Down (APD).** The capability of a device to switch itself from On mode to Sleep mode after a predetermined period of time (APD timing) has elapsed. APD timing begins when the following criteria have been met (U.S. EPA 2011b):

- 1) The device has ceased performance of all primary functions; or
- 2) The last user input has been received (e.g. remote control signal. volume adjustment).

**Service Provider.** A business entity that provides audio/video content to subscribers with whom it has an ongoing contractual relationship. A Service Provider distributes ENERGY STAR qualified set-top boxes to end users under a lease or rental arrangement (U.S. EPA 2011b).

**Conditional Access.** The encryption, decryption and authorization techniques employed to protect content from unauthorized viewing. CableCARD and Downloadable Conditional Access System (DCAS) are examples of conditional access technology (U.S. EPA 2011b).

**Digital Television Adapter (DTA).** A device that receives terrestrial (over the air) digital signals and converts them to an analog output suitable for analog TVs. DTAs do not provide digital signal output. This definition does not include converters for satellite or cable digital signals or devices that perform multiple functions (e.g. DVD players with DTA capability) (U.S. EPA 2011b).

**Game Console.** A stand-alone device whose primary function is to process video game content. The primary inputs for game consoles are special hand-held controllers rather than the mouse and keyboard used by a conventional computer. Game consoles are equipped with audio/video outputs for use with televisions as the primary display, rather than an external monitor or integrated display. Game consoles typically do not use a conventional general-purpose operating system, but often perform a variety of multimedia functions such as: DVD/CD playback, digital picture viewing. and digital music playback (U.S. EPA 2011b).

**Out-of-band Tuner.** A tuner compliant with standards ANSI/SCTE 55-1 2002. ANSI/SCTE 55-2 2002 or similar, that is used to gain access to data channels outside of the primary audio/video source signal. These tuners may facilitate two-way communication to allow a set-top box to exchange data (e.g. diagnostics) with the Service Provider. and may enable access to Pay-Per-View or other rich-media interactive content (U.S. EPA 2011b).

**Typical Energy Consumption (TEC).** A means for evaluating energy efficiency through a calculation of expected energy consumption for a typical user over a one year period. expressed in units of kWh/year (U.S. EPA 2011b).

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