Is the Smart Assistant Mutually Inclusive with IoT?

A Technical Paper prepared for SCTE•ISBE by

Charles Cheevers
CTO CPE Solutions
ARRIS International plc
3871 Lakewood Drive Suwanee, Georgia 30024
+1 678 474 8507
Charles.Cheevers@arris.com

Jonathan Wu
VP Product Management, Retail
ARRIS International plc
2450 Walsh Ave, Santa Clara, CA 9505
(408) 235-5500
Jonathan.Wu@arris.com

Table of Contents

List of Figures

Introduction

It seems that the smart assistant can do anything these days – including be the pivotal application to enable the service provider IoT solution. As service providers wrestle with how to deploy their smart home solutions, it's clear that the smart assistant is a key part of enabling the solution.

This paper takes the reader through some of the ideas circulating the industry and reviews:

- What is the correct inclusion of mic and speakers in gateway, access point, extender, set-top, and standalone devices?
- Inclusion of IoT radios in the same devices – what are the pros and cons?
- What is the role of the smart phone, TV, and smart assistants?
- Amazon, Google, and Apple smart assistants: friend, foe, or must-have partner?
- What is the role of AI, advanced speech recognition systems, and NLUs in the service provider arsenal?
- Can there be more than one voice assistant per home?
- Could there be multiple smart assistant solutions in a single service provider device?

This paper also reviews the role of IoTivity and the OCF as the potential basis for any service provider IoT hub and connection solution.

1. Smart Assistants and the making of the smart home

1.1. What is inside a Smart Assistant

The anatomy of the Smart Speaker has typically been the following
1. Wi-Fi subsystem that connects back to the home Access Point and onto the internet
2. Far field microphones – Amazon Echo debuting with 7 far field mics – but improvement in mic and DSP technology has now seen 4 far field mic's being sufficient to recognize human voice
3. Speaker subsystem – has the biggest influence on the size of the device – and typically ranges from 2W at the lowest level of voice only feedback to potential full high end soundbar instances of Smart Assistants at 50Watt and above
4. IoT and Low Power Radios – most of the Smart assistants focus on just adding BLE for pairing and authentication during onboarding of the device and to allow streaming of audio from and to other audio sources and sinks – most notably streaming music from smart phones.
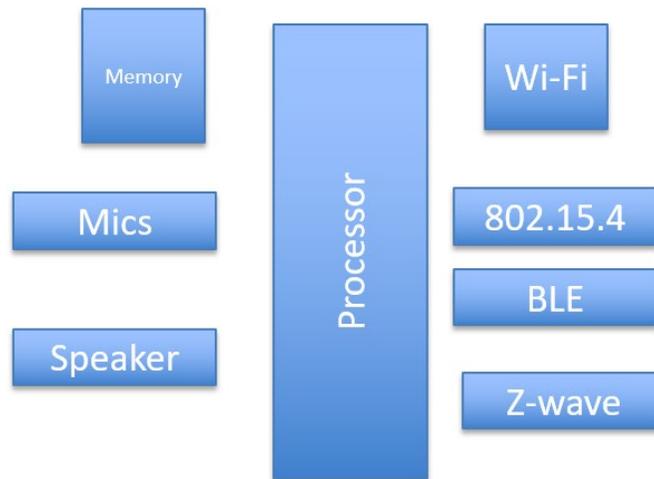
Figure 1 – The basic anatomy of the Smart IoT Hub

Figure 2 – The 4 for 1 insertion device

The other elements of the smart assistant that are key are

1. The "wake" or "barge word" – this is the spoken word that invokes the smart assistant and opens the logical connection to issue voice commands to the device
    a. Typically, this word is coded locally into the DSP – to ensure that the device – while always in listen mode is not sending audio from the home to the cloud/internet.
    b. Sometimes more than one "wake" word can be programmed. This will be the topic of a later section in this paper and one of the opportunities for the Service Provider.
2. The DSP engine which has a couple of functions
    a. Most importantly, to be able to pick out the "wake" word from background noise. There are several techniques for doing this that are outlined later in the paper.

b. Digitizing the vocal discussion and sending this digitized waveform to the cloud

3. The Cloud Voice Processing Engine
   a. While there can be local voice processing in the Smart Assistant – typically to be able to discern single word actions – all Smart Assistants typically rely on a cloud connection to the Automated Speech Recognition system. This ASR service processes the Voice commands or conversation through a number of levels
      i. Discerns language and then uses the appropriate language context to try and figure out what the person is saying.
      ii. Can discern who is talking to separate out speakers – using voice pattern as passwords or parental control or limiting access to certain skills and actions
      iii. Applies context to the voice command or discussion – as it tries to figure out what is spoken – it can use previous dialogs or specific learned words or items in dialog to help understand what is being said.

   For example if "Whats my Wi-Fi password?" is the spoken text , the ASR function may discern that this is potentially one of the following requests
   "Whats my Wifes password"
   "Whats my Wi-Fi password"

4. The cloud based Natural Language Understanding Engine
   a. One the ASR has tried to parse the digitized voice input to text strings – the NLU system tries to understand what the strings actually mean – using context and other elements to feed the NLU engine.
      i. The NLU process can be as simple as processing one sentence at a time or with the introduction of more sophisticated engines can now even engage in an interactive discussion to ensure that the assistant fully understands the request.

5. The Skills or Actions that are executed by the NLU when it understands the request
   a. This has been one of the most exciting part of the emergence of Smart Assistants and the core of this papers title. The ability to create a skills ecosystem that can be added to the smart assistant. These skills often run on devices that are not directly connected to the smart assistant but part of the IP network that can be accessed from the Smart Assistant. This could even include issuing a command to an Assistant in your primary dwelling home and executing the command in a Summer home 1000's of miles away to start video recording on a security camera for example. The ability for third party companies to include their products to be controlled by a smart assistant – is both hugely powerful but also makes the usability of IoT and Smart Devices work even better and breaks down the technical use inertia for the device.
   b. Today Smart Assistants add skills for more and more solutions and devices. This is primarily done by implementing primarily cloud API's that allow for example a smart device like a light to be controlled by a separate smart assistant. In this simple example a smart light bulb that is IP addressable creates a skill that is coded to support the cloud API's to the Smart Assistant. These are typically invoked by a voice command sequence like "Ok Jarvis Tell <Product Name> to turn on light bulb". The Product owner is given the command string and it then executes the Skill. Skills typically must be enabled and authenticated to the Smart Assistant in a preliminary step to allow the connection between the assistant and the out of band skill.

1.2. The undeniable trend of consumer pull for Smart Assistants

One in three homes now has a smart assistant device – Figure 3. This number does not include Smart Phone Smart Assistants like Apple IOS Siri or Google Android Assistant devices. The standalone smart speaker has become a popular addition to US and global household. This growth has been fueled by

strong pushes from companies like Amazon and Google making it a fundamental part of their core business (Shopping in the case of Amazon and Search in the case of google) and their desire to understand the consumer and their behavior more through more data gathering devices. The success of the Smart Assistant is also down in part to the continued investment in the Voice processing that has improved substantially over the last number of years to ensure that the assistant gets it right at 9 in 10 voice commands. This level of reliability keeps the consumer engaged with the device and the persona of the assistant!

Smart speakers ownership among US BB HH
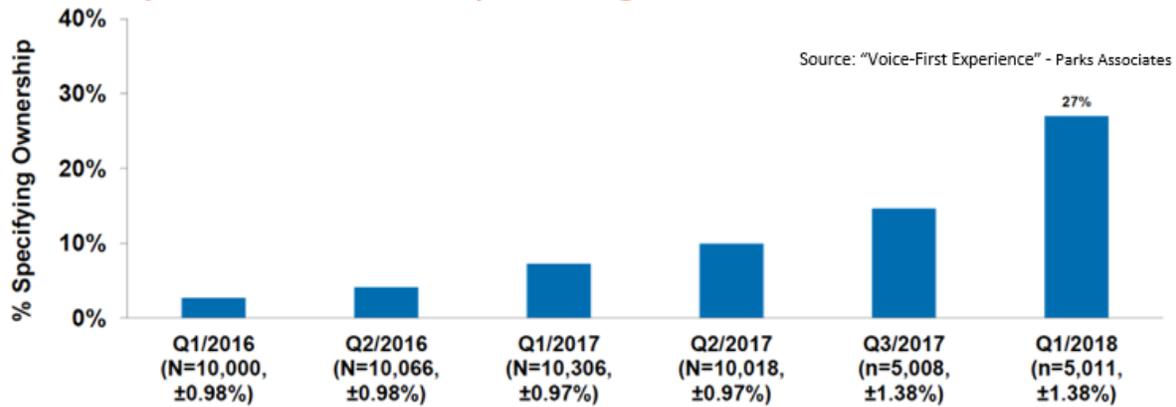
Figure 3 – The growing trend in Smart Speakers

The smart assistant is also the fastest growing home device with a projected 32% compound annual growth rate from 2017-2020 (see Figure 4) fueled by significant investment in Voice Processing, Natural Language Parsing and Understanding and alignment of the voice device with other growing services like Home Automation and Security solutions. Therefore, there is an undeniable link between the 2 worlds of Smart Speaker and IoT and why strong consideration should be given to rolling out both services together and potentially leveraging a single Speaker and IoT device in one solution. There are certain home factors – where people are mostly to engage in voice commands with Smart Assistants – which drive the decision on their type, location and effectiveness. This will be discussed later.

32% CAGR – the highest from all smart devices

Smart Home Devices by Category, 2017 and 2022 (Value in US$M)

Product Category	2017 Value (US$M)	2022 Value (US$M*)	CAGR, 2017 – 2022*
Video Entertainment	$133,091.48	$201,063.36	9%
Home Monitoring/Security	$4,271.30	$12,136.50	23%
Smart Speaker	$4,401.39	$17,431.00	32%
Lighting	$1,120.53	$3,511.32	26%
Thermostat	$1,774.35	$3,875.91	17%
Others	$17,532.54	$38,963.93	17%
TOTAL	**$162,191.59**	**$276,982.02**	**11%**

Source: IDC Worldwide Quarterly Smart Home Device Tracker, March 2018

A key device and function for the Service Provider to leverage !

Figure 4 – Smart Speaker growth vs other Home Devices

If we look at the trend of usage and skills in the 2 most popular smart speakers – Alexa and Google Assistant, we see from Figure 5 that Music and Audio still tends to dominate with Games and Fun growing fast too. However, you also now see the relevance to Home Control with 10% of the applications for Google Assistant being for Home Control. Additional services like IFTTT also help to ensure that thematic control can be affected across multiple different smart devices and those even developed by different companies. For example issuing a command like "Ok Jarvis Lock the House" could call an IFTTT script to lock every door lock, turn off and dim certain lights and briefly show the 4 outdoor cameras on the TV – before alarming the security system.

## Smart Assistants work well with IoT and Smart Home
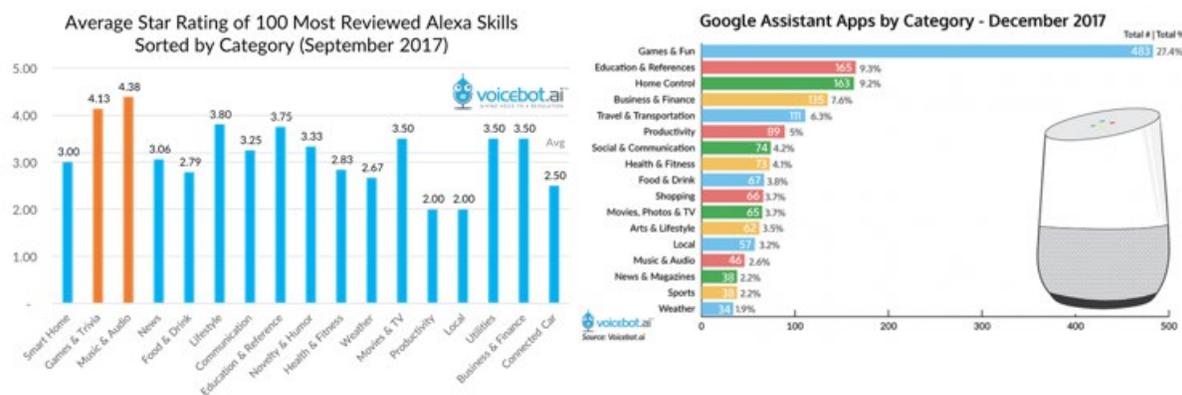
Skills growing to allow voice control of smart things !

Figure 5 – What people do with their Smart Assistant devices

Figure 6 below shows that Smart Assistants are still primarily being used for immediate audio feedback skills and tasks – like playing music and getting information. However, 15% of consumers are now using them with the Smart Devices – and this aligns almost 1:1 with the consumers who have smart devices in their homes. As the number of consumers who automate their home rises – so will the Smart Assistant's – as its clear that they are coupled in terms of similar consumer types.
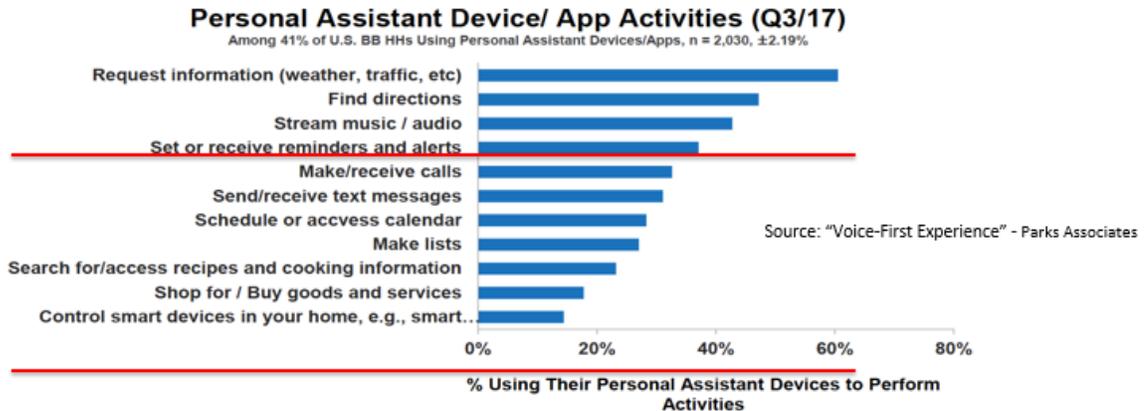
Figure 6 – What people do with their Smart Assistants

You can see from Figure 7 below that the projected uses of Smart Assistants with Home Control - ranges from Light control to being able to use voice commands with TV navigation and video content selection.
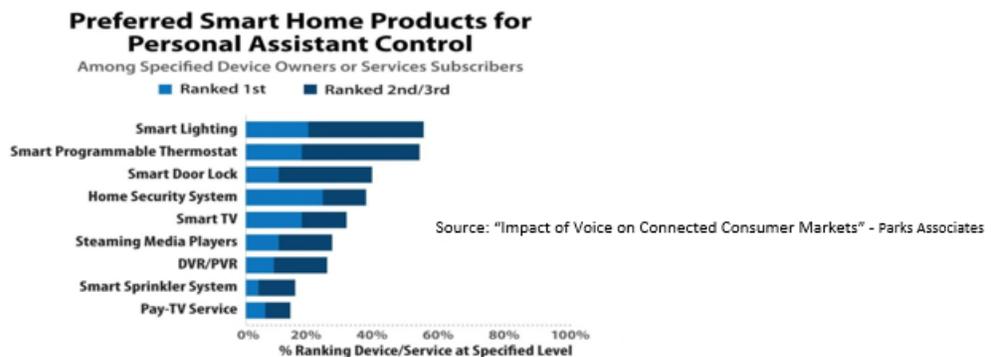
Figure 7 – What IoT services people most use with Smart Assistants

And there are future opportunities for revenue as part of Service Providers ecosystem to aggregate the different smart devices/services into one cohesive User Experience. New areas like Health and Education

also come into focus for the Service Provider to mine out the opportunities – with partnerships with Insurance, Public and Private Hospitals and digital education solutions
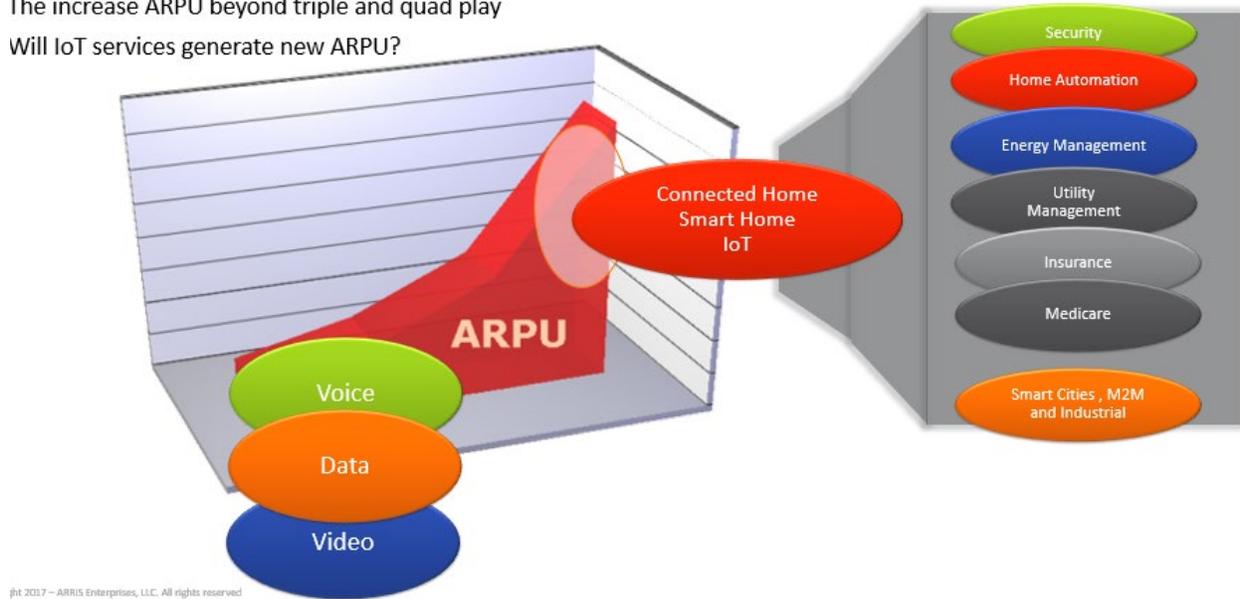
Figure 8 – IOT – its not just about turning on the lights

1.3. Where should Smart Assistants be located and in what physical form?

This is the most interesting and potential best opportunity for a Service Provider to leverage their existing presence in the home. When we think of Smart Assistants – we typically think of an Amazon Alexa device. This device is typically a standalone smart speaker that is added as another device to the home. Its typically designed as shown in Figure 9 and varies in size driven particularly by the Speaker power/volume. Current Smart Assistant devices don't typically perform the radio and protocol functions of an IoT hub and instead focus on working with additional consumer added IoT hubs that speak ZigBee or Z-wave. However, there is a trend growing to add ZigBee and even Z-wave additionally to the existing BLE radio – to allow the Service Provider Smart IoT hub – to support the onboarding customers bought IoT devices. By having all of ZigBee, Thread/Dotdot, Z-wave, IoTivity and BLE all in the smart IoT hub – this pretty much covers the vast majority of consumer bought IoT devices and gives them an IoT hub point as well as a voice assistant/smart speaker capability.

## Smart Assistant or IoT Hub
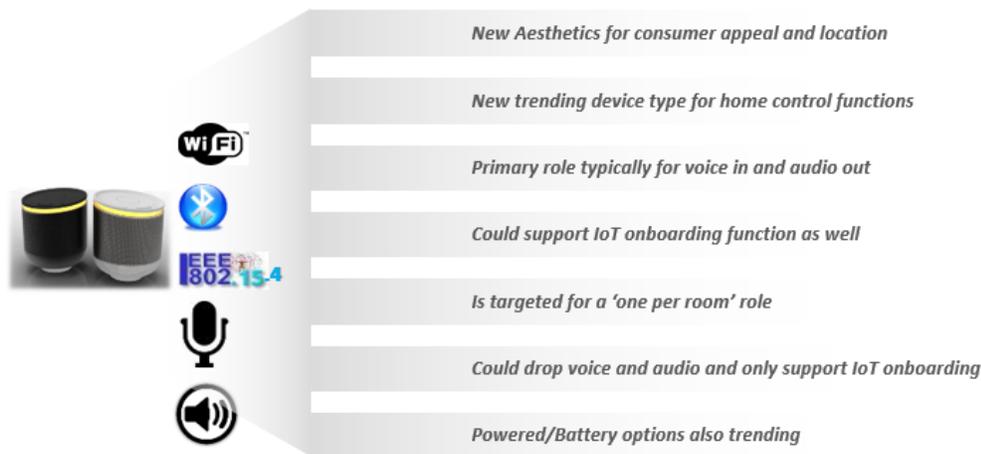
Figure 9 – What drives the design of the Smart IoT Hub

Figure 10 below shows the other potential options open to the Service Provider who already has devices in the consumers home. The Service provider has fought hard to get devices positioned in consumers' homes

- a. Gateway – typically 1 per home
- b. Wi-Fi AP – typically 1 per home
- c. Wi-Fi Extender – emerging now as typically required for at least 40% of US homes – particularly those over 2k sq ft
- d. STB – typically 2.3 STB per US home – all typically located in high footfall rooms

From a STB perspective it also offers unique additional elements of the Smart Assistant potential. In particular

- (i) Use of remote as push to talk voice input and TV speakers as Audio out. Great use cases for voice navigation of video content – but also increasingly being used for other Smart functions.
- (ii) The TV screen - Smart Assistant is typically associated with Smart Speaker where audio feedback is the main output UX. However, there is a growth towards Visual UX feedback that will be key to drive new services.
    - a. You can already see this being introduced with Amazon Dot and Amazon Show – where they have added screens for Visual UX output. A simple reason for doing this is that if a consumer is to buy products with voice – they really want to "see the product" to verify or confirm that it's the right one before letting the purchase complete.

You can see from what we have discussed that there are some practical considerations for Smart IoT devices

1. The location of the device.
    - a. It needs to be in rooms where people are and can engage with the smart assistant on a regular basis.
    - b. This for example usually means that Gateways don't make good Smart Assistant investments because many of them are biased towards outside walls and floor because of the location of the Coax outlet or Fiber drop.

2. Making the device too big – particularly with the addition of a high power / fidelity speaker. As we want to get devices like Access Points to be put on table tops – there has to be a balance in size and speaker performance to keep their footprint ergonomic for the consumer.
3. Associating them with TV – this allows the Smart IoT device to either potentially forgo the addition of speakers (at least powerful ones) and leverage the TV speakers -or- to leverage the TV screen for visual UX output and consumer feedback.
4. The number of devices (the capex investment) that are required to fulfill the voice input points in the home and the extension of an IoT hub mesh
   a. Smart Speaker – could be practical or at least somewhat used in every room of the house. Far Field Mic is typically tuned to be useful to 6-10ft of distance from the device.
   b. IoT hub – For ZigBee, Z-wave or BLE – it is not required to have a radio hub per Room as the range of these low frequency low power IoT radios spans a single room as well as the IoT end devices themselves typically mesh and add to the range of the network.
   c. For the typical home of 2.6 people and 2,500sqft it could be an optimal setup to have
      i. 2 specific Smart IoT hubs for 2 main use rooms in the home – Kitchen and Living Rooms typically
      ii. Leverage of potentially the STB with additional push to talk or Smart STB with Mic/Speaker added to extend to other media or TV rooms. In particular BLE in the STB for both Remote control usage and IoT hub/presence detection is a very usable feature.

The importance of far field microphones and speaker

Device potential for SA/IoT	Comments	Pros and Cons
Gateway	Tends to bias towards outer wall location	Con : Typically not in best position for voice interaction Pro : One device for smaller MDU/Apartments
Access Point	Has higher chance of being Table top and in room with high footfall	Con : Can make device bigger Pro : One device for smaller homes
Wi-Fi Extender	Typically put deeper in home and in room with people	Con : Trying to make extenders smaller and this adds to size Pro : Can be a 3 for 1 device to service
STB	2.3 devices per home Already many Remote Control 'push to talk' implementations in place	Con : makes the STB bigger Pro : In 2.3 rooms with high footfall
Smart Assistant/IoT device	New device type to	

Figure 10 – Where it makes sense to put Smart Assistant and IoT in the home
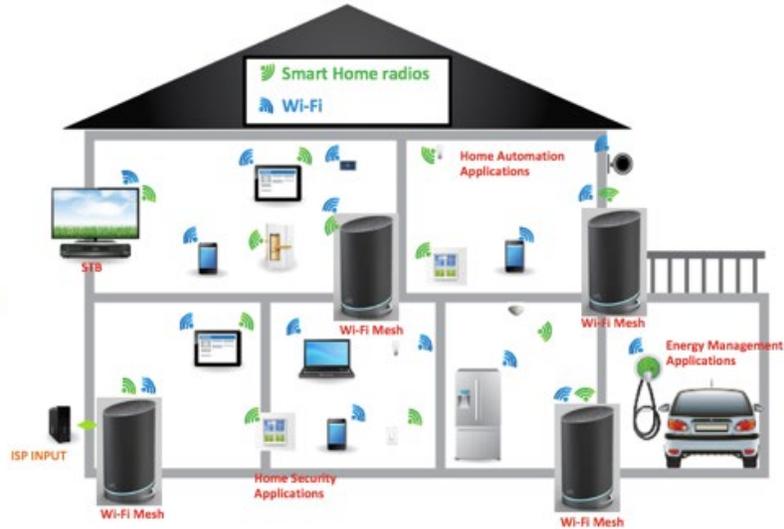
Figure 11 – Smart Rooms not Smart Home

1.4. The STB as the Smart STB with a splash of BLE IoT

As described above the STB has the distinction of being in typically at least 2 high traffic rooms in the US. And the STB is typically, 6-8ft from most people. It also controls the TV as the largest screen(s) in the house – a new canvas for adding visual UX output from voice engagement with home services.
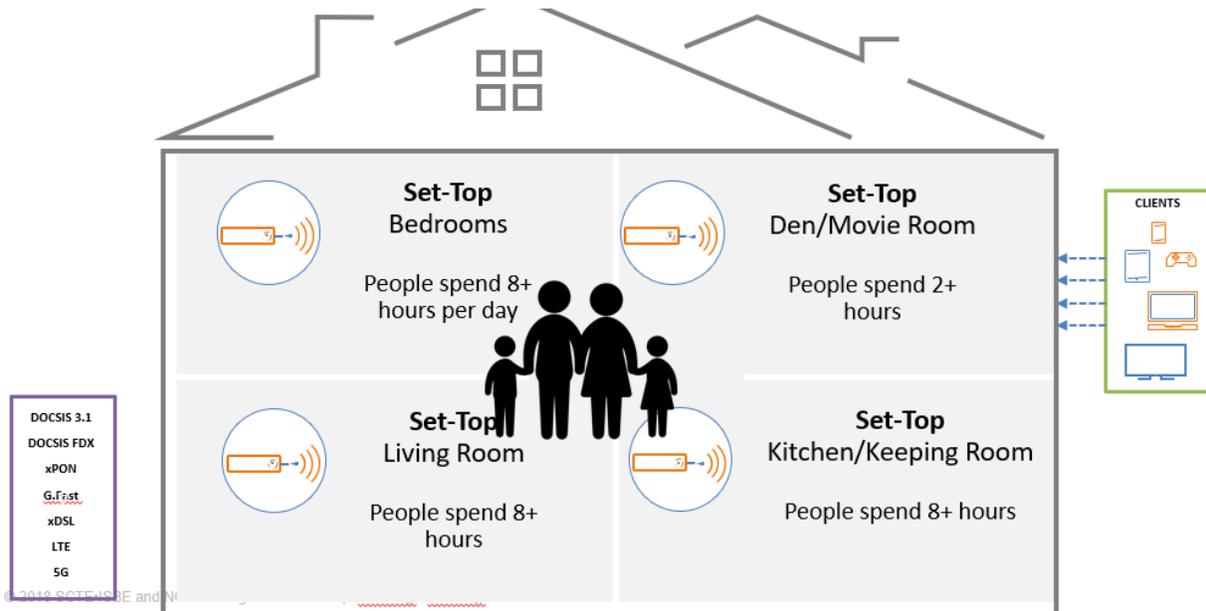

Figure 12 – Why the STB is a key device to make Smart

From a Service Provider perspective – it also has the ability to leverage as a 5 for 1 device which is a powerful capex reducing option as well as helping the consumer with both ergonomics and aesthetics (less devices) and overall power utilization in the home.

The 5 for 1 elements are depicted below in Figure 13

i. The fundamental function – the STB video function. However, this video display function now also extends to support visual UX feedback from Smart Assistant inputs and Skills

ii. Smart Assistant – the addition of far field Mics or even push to talk remote with near field Mic – can turn a STB into a smart speaker. The TV providing the speaker functionality. Using the TV as the speaker to the voice input – has one problem – when the TV is off – the smart assistant audio feedback is also off. There are potential workarounds to this

    a. The TV could be on a smart switch that could power it up. This is not a good user experience waiting the 10+ seconds for the TV to power on

    b. Using HDMI CEC input – to wake a TV from standby to generate the audio feedback. A better experience at typically under 10 seconds to sound output.

iii. IoT hub – with the addition of BLE for Remote control and audio streaming the STB could also then provide BLE hub functions to BLE based IoT devices. Consideration could also be given to add either/or both ZigBee and Z-wave to cover as many consumer owned smart devices

iv. With the extension of a Soundbar with STB integrated – a single device can now cover the video and audio requirements for all services.

v. Remote Control – the Smart STB could be deployed without a remote – and just use Voice to navigate all services – from Video/TV to IoT services.

Smart Assistant to be built into the predominant UI

Mobile App for IoT applications
- Set-up is still done using an App
- Smart Assistant to run scenes

Remote control for a STB
- Smart Assistant to trigger simple tasks
- Feedback provided on display. Further navigation to be done on remote control or Smart Assistant

Figure 13 – Its not just the phone app – it's the remote and TV too

As can be seen from Figure 2 below – there are probably 4 Smart STB architectures (2 depicted below)

i. Addition of push to talk remote with near field microphone using RF4CE or BLE – cheapest way to overlay smart assistant functions

ii. Addition of 4 far field microphones to small form factor STB – to turn it Smart

iii. Addition of 4 far field microphones + 2-4W speaker to the STB – mass market device

iv. Addition of Smart STB to a soundbar – Higher End device that appeals to about 20% of consumers or more at lower prices.
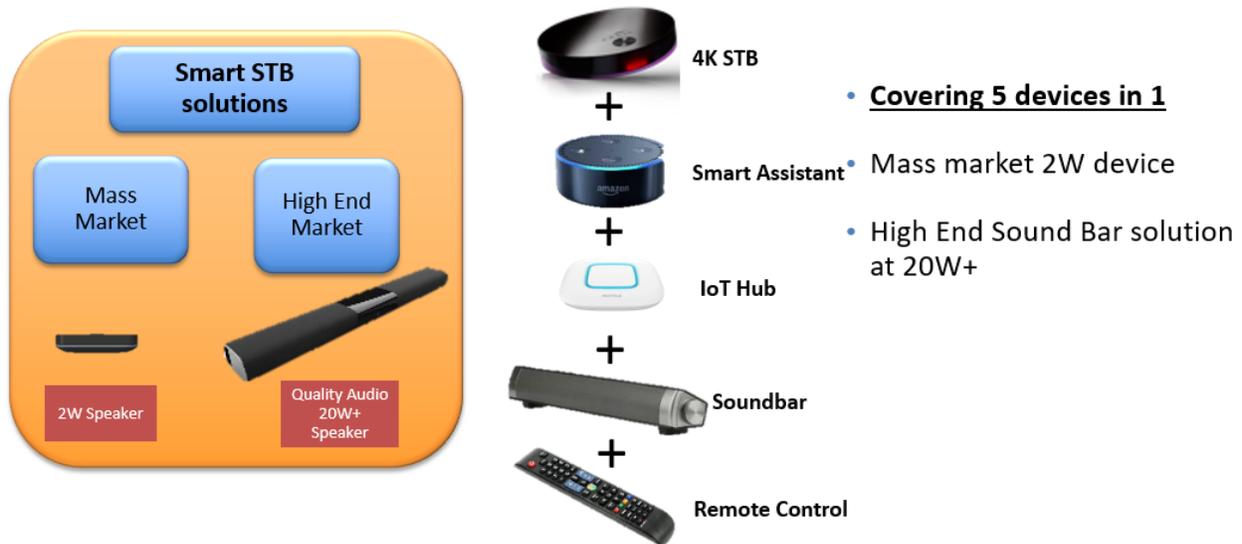
Figure 14 – The 5 for 1 opportunity with the Smart Media Device

2. Which IoT protocol and which Assistant or can there be more than one?

Service Providers can do one thing better than all the major IoT and Smart Assistant players can on their own. They can aggregate the services and the devices into one cohesive experience for the consumer.

From the IoT perspective the following is the high level take on the Radio protocols

  i. 802.15.4 – ZigBee
      a. ZigBee has a very mature and strict data model for its IoT ecosystem. This makes it straightforward for a Service Provider Hub to control third party ZigBee devices and customer owned and managed (COAM) devices.
 ii. 802.15.4 – Thread
      a. Thread also runs on 802.15.4 and has a well enough defined data model to easily aggregate Thread based devices.
      b. ZigBee and Thread coexist and the Dotdot standard supports ZigBee over IP
iii. BLE
      a. Bluetooth is more difficult to take ownership of COAM devices. The BT data model is not strict enough that its often required to develop specific code on a device per device basis to guarantee its interoperability
 iv. Z-Wave
      a. Strict data model that allows it to support Service Provider aggregation.

Additionally, the Cable industry is also supporting the Open Connectivity Foundation and the Opensource standard IoTivity. The OCF absorbed both the UPnP and Alljoyn assets in the last 3 years and has a S/W architecture that works very well with the aspirations and future directions of the Service Provider. Using the IoTivity Server and Plug-in support it has for Protocols like ZigBee, Z-wave, Thread and BLE – it makes a powerful interface layer to be able to host an IoT protocol engine at the same time supporting RESTful cloud interfaces and protocols like COAP, MQTT and even the RDK-B WebPA protocol.
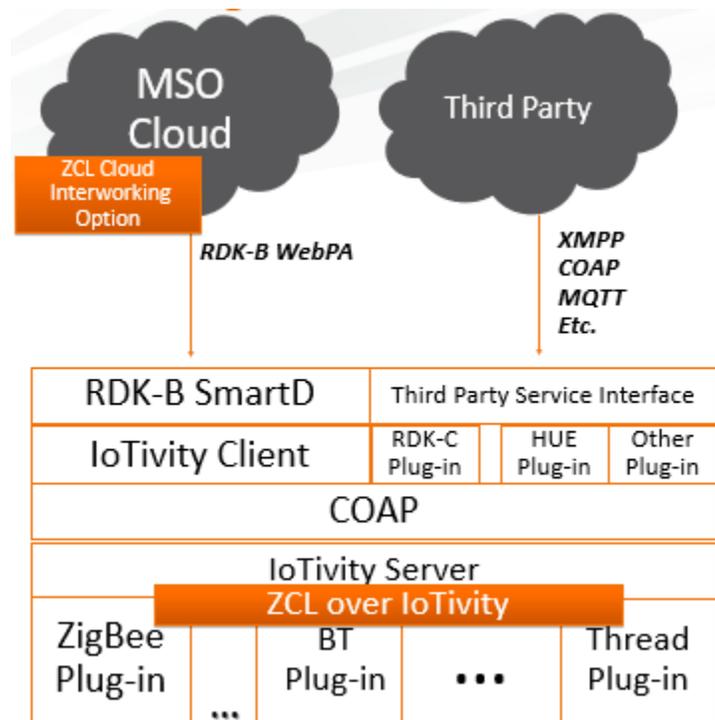
Figure 15 – The Simple Cable IOT Stack

The use of a Smart Assistant ASR and NLU and Skills Framework/Store is the more interesting discussion.

Options exist to

i. Develop your own ASR and NLU and support your own specific Wake work in your own specific Smart Devices
   a. This is the most expensive option and requires a large development team with specialized skills in Voice processing and definition of Natural Language understanding and related skills and actions.
      Very few if any Service Providers will go this route – because of expertise deficit, expense to implement or contract out. Complexity of Language support does sometimes drive towards developing specialized regional ASR solutions.
      The benefit of doing this – is that you own all the data mined with Smart Assistant interactions.
      The negative is that you must implement everything including Web searches and try and bring up a comprehensive skills solution.

ii. License ASR from independent ASR solution providers, license NLU for Web queries ("What is the weather today") and develop or contract your own NLU for specific Service Provider Skills ("Whats my Wi-Fi password, Buy more broadband"). These skills require integration into the Service Providers own backend.
   a. This is a path followed today by several Service Providers today – especially for TV navigation services and basic web queries with voice.
      The benefit of doing this is that you broaden the Voice Assistant skills (license costs are expensive) but keep your customers analytics.

iii. Decide to leverage one of Google, Amazon, Cortana, Watson, Bixby, others – solutions.

   a. Develop skills for these ecosystems that drive Service Provider services but through the presence of the third-party device
      i. For example, develop Alexa Skills to navigate TV or other SP services. Add this skill to the Alexa Skills database.
   b. Add the ASR or NLU to a Service Provider device – standalone Smart Assistant or integrated into existing device like AP or STB

   Both these options leverage the very broad and feature rich solutions of each ecosystem – but offer the ASR/NLU provider the analytics of what the consumer is doing. The debate then is to whether allowing one of these companies to engage with 'your' (Service Provider) customer is a threat to your own service directions. While the ASR/NLU providers claim they maintain privacy and don't really use the data – this is debatable as there is at least trend and frequency patterns that also offer consumer insights.

   iv. Possibly the best option (and potentially unique to Service Providers) is one where there are multiple Smart Assistants in the Service Provider device.
      1. The scope exists to be able to add multiple wake words to the smart assistant device
      2. Based on the wake word selected
         a. Alexa – invoke Amazon ASR/NLU – could add Service Provider Skills but don't have to – "Alexa Tell <Service Provider> to.."
         b. Ok Google – invoke Google Assistant ASR/NLU and tasks – could add Service Provider Skills bit don't have to " Ok Google Tell <Service Provider> to.."
         c. Ok <Service Provider Name Here) whats my Wi-Fi password.
      3. For the Service Provider specific path – the following elements are in play
         a. Only implement ASR and NLU for specific value add SP skills
         b. Keeps the analytics and data from the Amazon and Google clouds

See the Figure 16 that illustrates this below
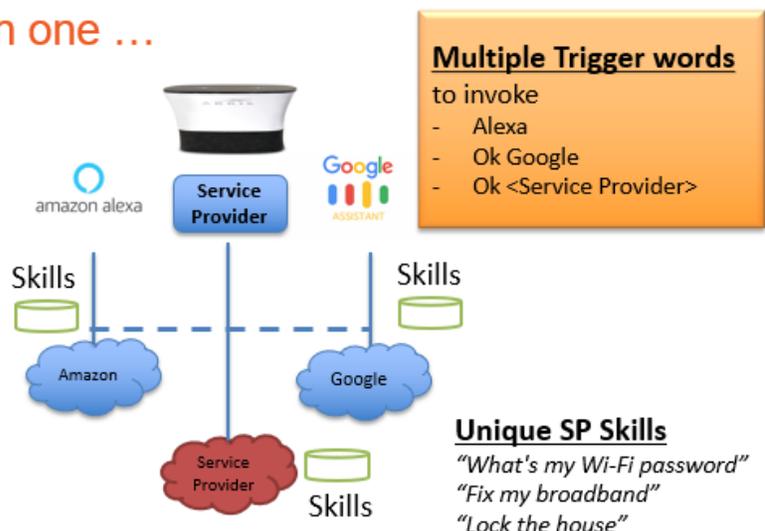
Figure 16 – Multiple Smart Assistants are possible.

Figure 17 below denotes the flow control path from Voice DSP to the various ASR and NLU elements.
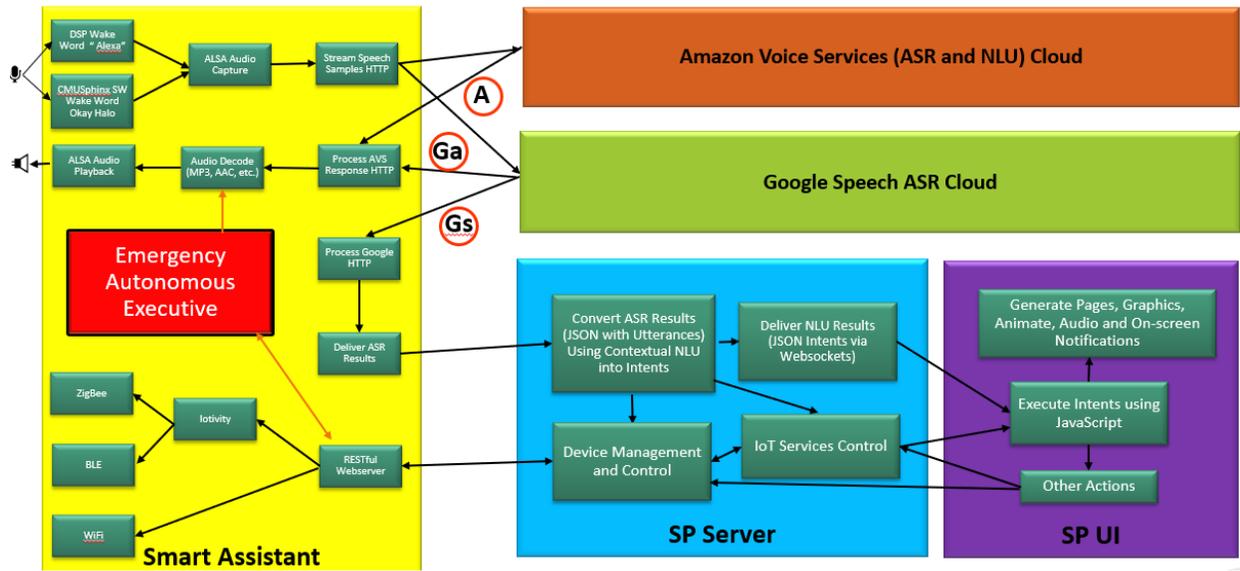
Figure 17 – The flow of voice from Mics to ASR

Examples of the unique set of Service Provider skills include

- *OK Service provider, what is my Wi-Fi password?*

- *…, how fast is my broadband?*

- *…, can I get faster broadband?*

- *…, how much more will I pay for faster broadband?*

- *…, upgrade my broadband*

- *…, open my guest network*

- *…, secure my guest network,*

- *…, what unknown devices are connected to my net?*

- *…, shut down my son's Wi-Fi from 8PM on weekdays*

- *…, what parental controls are active?*

- *…, what devices have poor connection?*

- *…, fix my wife's iPad connection*

- *…, show my front door webcam on den TV*

- *…, block my webcams from the Internet*

- *…, connect me to support center*

And one of the most opportunistic areas to apply Smart Assistant services is to provide customer self healing and interface to Chatbot and future AI services for customer support.

It is not hard to imagine a scenario where the consumer does not use to the phone at all to contact the Customer support desk. Instead it uses smart assistant to ask 'Ok Service Provider – I'm not happy' ; 'Ok Service Provider – my Wi-Fi sucks' ; 'Ok Service Provider Fix my iPad' ; 'Ok Service Provider – upgrade me to 1Gbps service'

These are powerful new automated features that can reduce customer call center Opex, increase consumer NPS scores and also potentially unlock new pay for services opportunities.

There is still ongoing debate and dialog around

a) Are Service Providers compromised by integrating with large company ASR/NLU – and are they competing for the same consumer?
b) Is there opportunity for both Service Provider and ASR/NLU provider to profit together? Certainly, the aforementioned ASR/NLU companies are offering SDK and Cloud API's to integrate their ASR/NLU Solutions.
c) What is the risk of sharing the analytics from Consumers with the ASR/NLU providers?
d) Is there a hidden cost associated with using these -on the surface- free to use – ASR/NLU SDK's?
e) Will consumers be confused with different wake words and different Assistant persona's in the same device?
   a. Some point out that we already do it today – with Siri on phone and Alexa at home – and we are already distinguishing what each assistant does for us.
   b. Some will point out that who owns the responsibility if something goes wrong? If you ask the multiple persona smart assistant to "Lock the house" and it is not done. Which one is responsible or is there some accountability ambiguity.

There is also some reluctance of the ASR/NLU to also certify solutions that support Wake words that don't invoke their Assistant. Amazon at this point – will certify devices that support other assistant's resident in parallel to their own Alexa.
Google, at this point are not certifying devices with multiple Smart Assistant Personas. They are reviewing the scope to boot to one from several options presented but not all resident together. This is something our industry should lobby to Google to open up this multiple wake words potential and compete on their own merit of consumer wanting to use there services.

One last point to make here – is that several years ago – the Cable industry was very wary of the rise of Netflix and viewed them as a competitor to keep at arm's length. As more Netflix end points were updated with Netflix App downloaded to Smart TV and OTT STB – it became clear that the best strategy for Service Provider and consumer alike was to integrate Netflix as just another video source – with deep metadata integration being an even better user experience. This has proven to keep the consumer on the Service Providers device even when in Netflix app and always returning to the same HDMI port that the SP's own services run on.

The same analogy could be applied to Smart Assistant ASR/NLU providers – that integrating them into Service Providers own solutions offers the control still to the SP vs consumers (1 in 3 has one now) adding devices to their homes that the Service Provider is blind on what is being asked from the home.

Conclusion

As the highest growing CPE device – the smart assistant remains a function that the Service Provider must embrace. Couple the growing trend in Smart Home devices – it seems like there is a perfect storm brewing of the interception of IoT and Smart Assistant. This provides the option to put them together – probably even in the same device based on their almost 1:1 relationship and their coverage of voice input and IoT mesh coverage in the typical home. There are certainly lots of decisions to make – like speaker size or whether to integrate into STB. However, the most important decision to make is on ASR/NLU selection. This paper outlined the potential to have more than one – and to leverage the investment of other companies on NLU/ASR to allow the service provider to implement key , critical Skills that are specific to them and their customers – affording the best leverage of Smart Assistant services for their customers.

Abbreviations

ASR	Automated Speech Recognition
NLU	Natural Language Understanding
BLE	Bluetooth Low Energy
ZCL	ZigBee Cluster Library
RDK	Reference Design Kit
SDK	Software Development Kit
AP	Access Point
STB	Set Top Box
OCF	Open Connectivity Foundation
SMD	Smart Media Device

Bibliography & References

Source : "Voice-First Experience" – Parks Associates
http://www.parksassociates.com/bento/shop/whitepapers/files/Parks%20Assoc%20Enabling%20Voice%20in%20the%20Smart%20Home_WP.pdf

Source : "Wordwide Quarterly Smart Home Device Tracker, March 2018" – IDC
https://www.idc.com/getdoc.jsp?containerId=IDC_P37480

Source : Voicebot.ai https://voicebot.ai/

Source : "Impact of Voice on Connected Consumer Markets" – Parks Associates
https://www.parksassociates.com/whitepapers/voice-may2017