EVOLVING THE HOME ROUTER TO AN APPLICATIONS DELIVERY GATEWAY

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Abstract

The home router has become a power house of performance, enabling a dizzying number of devices in the home to communicate with each other and the internet at ever growing bandwidth and capacity. With all this impressive brawn, it is easy to overlook the router's potential for brains.

The home router is an always-on device that is completely intimate to the physical and logical connectivity between devices on the home network and their connections to the internet. That intimacy makes the home router uniquely positioned to host a variety of applications.

In this paper, the authors discuss some of the applications that can supply a brain to accompany the brawn for next generation routers. Some example applications discussed relate to Machine-to-Machine (M2M) communication for home control and security, Personal Content Management, and Advanced Home Network Management. While this list is not exhaustive, it gives a fair idea about the possibilities and opportunities for the Service Provider to move up the value chain, while continuing to delight the customer.

INTRODUCTION

Until now, the nearly complete focus of the home router's evolution has been on improvements in the performance of IP connectivity, while the router's own participation in using that connectivity has been suppressed, maybe even discouraged. One could say that the focus has been on brawn - faster speeds - over brains. The time has come to turn some of that focus towards developing gateway intelligence by way of hosted applications for which the home router is uniquely positioned and qualified.

WHAT KIND OF APPLICATIONS AND WHAT MAKES THE ROUTER QUALIFIED?

A home router is not suitable for every kind of application. It has no keyboard, no joystick, no screen nor speakers of its own. Hosting games, word processors or corporate payroll applications makes no sense at all. The best applications for it to host are those that leverage and extend its innate properties. Simply put, those key properties are 1) It is always on; 2) It is connected to the internet; 3) It is intimately connected to every IP device in the home. Taking the concept one step further, an integrated home router with built in broadband access, such as DOCSIS® 3.0, xPON or bonded DSL, would expand the reach of the hosted applications into the WAN (see Figure 1).

The always-on nature and therefore its ability to continuously access both the internet and devices on the home LAN make the integrated home router the perfect place to host

applications that need to provide one or more of the following properties [brain functionalities]:

- Anytime or always-on availability [always thinking]
- On demand or near real time access/control to devices on the LAN [gross motor skills]
- On demand or near real time access to devices on the *once-removed** network [fine motor skills]

* The "once-removed" network is the collection of devices in the home/office that are not necessarily directly IP connected, but can be controlled and/or monitored by other devices that are in turn IP connected. Examples of some technologies that can act in the once-removed network are Bluetooth® (1), ZigBee® (2) and Z-wave® (3)

- A high degree of local abstraction to hide, when necessary, the complexity of the local network or the once-removed network. This allows for more uniform and less complicated communication protocols between the Cloud or other internet devices on the LAN or the once-removed network [can process the environment to abstract and simplify clutter]
- A high degree of local autonomy and in-depth local knowledge to discover WAN, LAN and once-removed topology [is self aware and can communicate it's condition]
- A high degree of local autonomy to help in scaling or offloading from the Cloud or management system [thinks for itself, but is a member of a community]

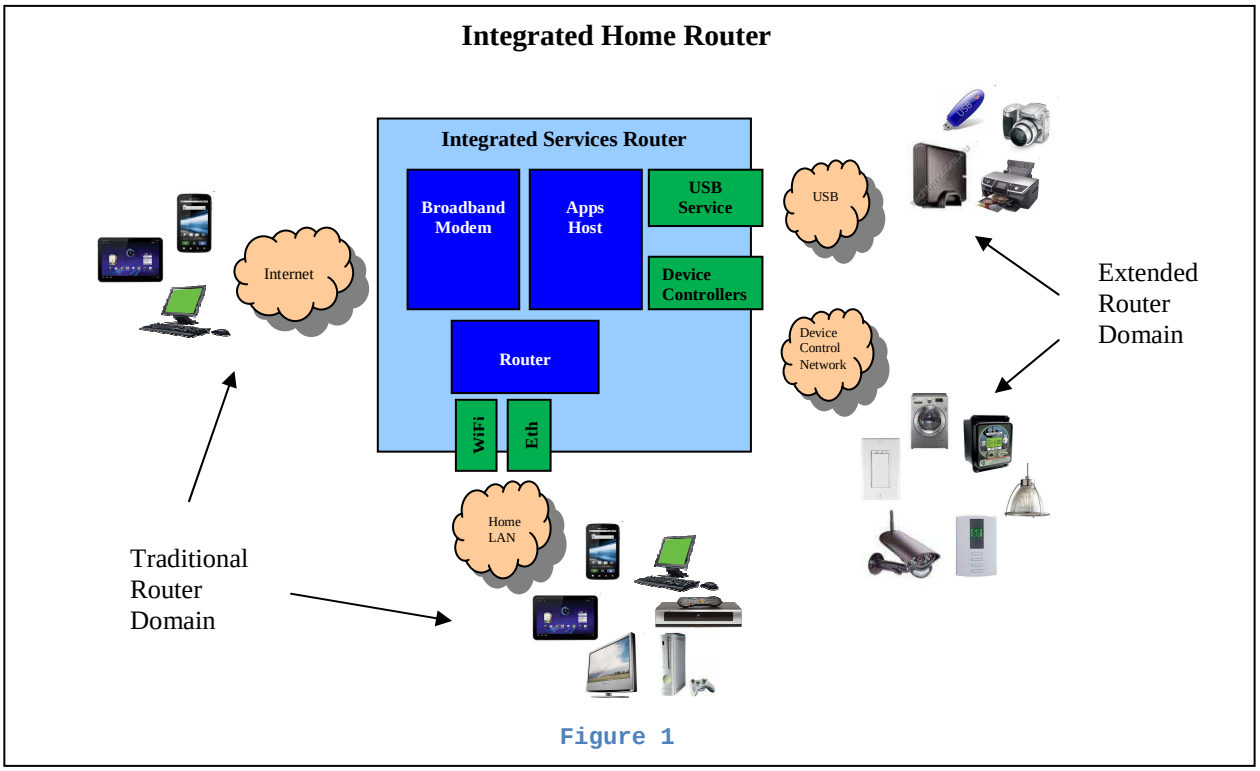

Figure 1

M2M CONTROL POINT APPLICATIONS

Some of the most interesting examples of applications which are ideal for integration into the home router are Machine-to-Machine (M2M) control points. Of course the concept of one device "remote-controlling" another device is not new to the internet. In the most basic sense, M2M is one smart device talking to another smart device via a communication network (4) . In industrial applications, such as on a complex factory floor, M2M has had natural and wide adoption, albeit for a closed environment and a non-consumer market. For the home/consumer market new possibilities are just beginning to open up.

There are several emerging genres of M2M applications for the home. Each of these genres is best serviced from a Cloud portal vantage that can homogenize the presentation to the end users, simplify presence and discovery of devices from across the internet, and be the integration and launching point for service extensions or other services supplied by the service provider. That said, hosting the control point portion of the application in a home router with its integrated WAN or broadband access and direct connectivity to the LAN and once-removed network provides the best solution for the service provider to deliver, control and manage the entire experience.

Home Automation

Examples of features in this genre include the ability to remotely turn on your sprinklers, turn off your air conditioner, turn on or off lights or even unlatch the dog door from a smart phone, computer or hosted scheduler. These are convenience features once only available to high end homes via highly custom installations.

Home Security

Features in this genre would include remote enable/disable of the alarm system, monitor/control of individual sensors (window, door, and motion), and control of camera pointing, scanning and live/recorded viewing of video feeds.

Home Energy Management

Features in this genre would include remote monitoring of total home power usage and/or usage on a per-device basis. Historical analysis of telemetry can be used to detect and correct consumption patterns. Available interfaces to the utility company's portal can be utilized to create useful correlations and validations of power consumption, including actual costs incurred due to specific power consuming devices such as air conditioning, clothes driers and entertainment clusters. Triggers could be used to inform the homeowner of a "violation" in progress, such as the drier being turned on during peak usage or peak billing hours. That alert could come, for instance, as an SMS to a cell phone or an alert ring and pop-up on a custom smart phone app.

Senior Care Monitoring

Features in this genre would include monitoring door sensors, motion sensors and pressure sensors to allow passive monitoring of the elderly or infirmed. Cameras could be added for more complete, but more intrusive monitoring. Triggers such as lack of motion for a prolonged period (have they fallen?) or opening of an off limits door (the front door leads to traffic or dangerous stairs) could alert a care giver and prompt a phone call, visit or emergency action.

Advanced Medical Monitoring

Features in this genre would include gathering telemetry from scales or other medical equipment such as heart rate monitors and glucose meters. For advanced medical monitoring, security, senior care and home automation could be combined. For critical care, perhaps FDA certified/approved devices for M2M applications have a market place.

It is important to note that these home oriented M2M features are not just about one-way remote control services into the home. Their best utilization is when a diversity of machines takes advantage of their local capabilities to build something more useful.

Here's an example of a fully automated M2M scenario that one could envision being easily "programmed" by an end user from a properly equipped smart phone. Using the phone's GPS, the phone can detect when it has moved one mile away from home. Using this event as a trigger, the phone can interact with the M2M network (via the Cloud to the home M2M control point) and cause the home doors to lock, the home alarm system to enable, verify and close the garage door, send an SMS

or email from the phone to the elderly care service provider that the person has left the house and even pop open the doggy door to prevent an embarrassing accident.

Some major operators have already entered the home M2M market place and are deploying solutions. These kinds of engagements are expected to grow and help drive technologies and monetized deployments at an accelerated rate. Industry initiatives, such as the TIA's TR-50 (5) and ETSI M2M (6) promise to further standardize the M2M ecosystem and bring a plethora of interoperable service opportunities to the telecommunications industry.

PERSONAL CONTENT APPLICATIONS

Another natural set of applications for an always-on home router have to do with file storage and media access. Network attached storage (NAS) systems for the home are not new, but their presence in the marketplace appears to be growing. Digital photo, music and movie collections grow rapidly, but are almost always spread out over many devices (phone, tablets, cameras, computers). The desire to ease the ability to collect files from these devices to a central location is becoming more urgent.

Collecting the media (copying) to a central location provides a back up to the phone or camera against disaster and provides a place to store when the internal storage of the device becomes full. When a consumer consolidates media, they typically choose to use a home computer's hard drive. This approach is fine for back up and overflow storage, however, it can have some serious limitations.

Setting up an environment where other devices on the home LAN can access that computer's hard drive is complicated and not guaranteed to interoperate across varying devices' operating systems. Remote access from the internet to the computer's hard drive is not possible without special software on the computer. Maybe most limiting is that a computer can be turned off or in the case of a lap top, not even be at home. An always-on integrated home router with attached storage capabilities provides a platform to overcome these limitations.

There are several NAS devices in the market today that can be plugged into the Ethernet port of an existing home router. With enough patience to configure the NAS and the IT properties of the router, many solid features become available to the end user. These features typically include: SAMBA (LAN) access to files available on the NAS; DLNA-Server streaming of media files stored on the NAS to the growing list of compatible devices on the home LAN, including game consoles, MAC and Microsoft OS computers, Wi-Fi™ enabled TVs and Blu-ray Disc™ players; and remote access to files on the NAS from the internet. Remote access capabilities can be extended to social media and file sharing features, with mailing lists and automated posts to social media outlets.

All these features can be supported with a NAS application integrated in a home router. Several additional benefits over a standalone NAS are available if the Router/NAS

combination also contains an integrated broadband modem.

Automated Configuration

Since the NAS, router and broadband access are integrated into a single box the configuration is automated. The user doesn't need to know how to configure the router to grant the NAS access, configure DHCP to get it on the network, or assign ports and port forwarding rules to allow internet access.

Advanced Management

It was noted above how an integrated device can automate the configuration tasks. In a service provider deployment there are additional advantages in the ability to manage and monitor the modem, router and integrated NAS as a single entry. A standard retail standalone NAS has no remote management capacities, such as TR-69 or SNMP. A full integration eliminates this problem, enabling the operator to have a much better position to manage a deployment. The combination of automated configuration and advanced management can be a great aid in customer satisfaction and customer loyalty.

Hardware Cost

The cost savings to the operator or as passed on to the end user of a consolidated box could be significant. The cost of buying separate modem, home router and NAS devices can stack up as compared to buying an all-in-one integrated router/NAS device.

Converged Commercial Media Routers

The advantages above will become even more pronounced as the traditional video set-top box continues its evolution towards the IP video gateway. The need to distribute live, on-demand or recoded video to devices on the home LAN will magnify the need for an integrated home router. SOCs which enable IP video distribution capabilities inside an integrated home router will start to appear in the market place in 2012.

ADVANCED HOME NETWORK DISCOVERY AND MANAGEMENT APPLICIATIONS

As stated at the beginning of this paper, until now the focus of the home router's evolution has been on improvements in the performance of IP connectivity. This performance increase is the great enabler of our time. The importance and continued evolution of throughput performance can't be overlooked and must continue for the foreseeable future. However, with all these improvements comes a drawback that must be overcome – high complexity.

Year over year the worry has been stated that lack of bandwidth would cripple quality of service (QOS). There have been numerous strategies to head this crisis off with advanced QOS methodologies, only to find that timely, cost effective technology advances in performance bail us out. It seems that a lack of bandwidth may not be the killer of QOS. The pipes keep getting bigger, symbol rates denser, spectrum more available and diversity transmission techniques ever more standard. However, it may be the complexity and digital clutter associated with this level of improved performance which could be the killer of QOS.

Bonded DOCSIS® 3.0, bonded DSL, 3G, 4G, Gigabit Ethernet with more ports, MoCA®, HomePNA®, multiple SSIDs per multiple Wi-Fi radios, HomePlug®, L2 tunnels, VLANs, VPNs, dual homed WAN - the list seems endless. The technological complexities and home-by-home variations of devices and interfaces have exploded. A typical home is starting to look like an enterprise deployment. But unlike an enterprise, every household cannot afford its own IT department. Compound this with the fact that traditional TR-69, SNMP and other call center techniques are insufficient to scale to the situation without some paradigm shifts. For the most part, current management systems are set up to query the discrete values of pre-known parameters internal to the router's configuration. These techniques are almost blind to the fluid nature of the devices on the home LAN.

A solution to solve this scalability and variability problem is to put much more intelligence and autonomy in the home router. This locally hosted application can analyze the network, detect issues and alert the user or customer care agent of a problem and where to fix it. Better yet, take this local intelligence to the next step for analyzing trends and alert and/or correct an impending problem before it becomes service affecting.

Network Discovery

Keeping track of what devices are on the home LAN can be a challenge. IP enabled computers, tablets, phones, games, set-tops, TVs, Blu-rays, printers, file/media servers and many other devices are popular in the home. How does an operator, customer service agent or even the home user know what devices are connected right now and what the expected properties these devices have so they can help setup or debug the home network? Current TR-69 or SNMP techniques can query some standardized MIBs to get some modem, DCHP, Wi-Fi information and perhaps a few more general router stats and try to interpolate a bigger picture. This can take many queries and still leave the agent without critical information.

Of course the integrated home router is the perfect location for hosting a Network Discovery application. It intrinsically has access to many pieces of information such as DHCP lease table and switch/Wi-Fi learning tables. It can ARP scan for devices that may have statically joined a subnet. Further probes and traffic monitors can discover UPnP devices and their capabilities and probe local IP devices for HTTP Web page capability. This gathered data can be used to create a small database representing the discovered nodes on the home LAN, how they are connected and most important, useful information on each device.

This database is easily exposed for use on the router's local UI to draw a network map that can be drilled down with mouse clicks or as a file which is available to a management system for it to draw the map for a customer service agent. The management system application that uses the topology database can then further augment diagnostics and corrective action by using traditional SNMP or TR-69 management objects.

Network Histogram

The Network Discovery application embedded in the router can automatically refresh the topology database at regular intervals. Changes in targeted parameters from a baseline can be recorded at regular intervals. With this method the database then becomes a histogram that can be useful in capturing variations and instabilities in the network. For instance, it could see that a fixed position Wi-Fi device intermittently drops on and off the network. Imagine the frustration saved by the customer care agent who can actually react with more than just sympathy to a customer saying "Well, it was happening this morning before I called!"

Trend Analysis and Alert Triggering

This application realm dives deeper and takes a running statistical look at the core access technology interfaces. Using various interfaces' instantaneous measurements and counters available on the integrated router, the application can collect, record, average, filter and analyze trends that can be used to take preventive action before an outage can occur.

Let's take a DOCSIS® 3.0 bonded down-stream connection as an example. In a typical DOCSIS® 3.0 modem the downstream could consist of data distributed on 8 individual channels (QAM modulated data on 8 frequencies) that are captured and re-sequenced in the modem to create a 300Mbps connection. Each channel is subject to its own analog variations in signal quality due to minor Tx power fluctuations and interferences. In nominal operating conditions, digital receiver techniques are transparent to this "noise". However, if one or more channels degrade such that transmission errors become significant, then performance and connectivity will quickly degrade and perhaps result in an outage and a truck roll. Having a remote management system poll many measurements 24/7 across 8 channels is neither realistic nor scalable across a large population of devices. Furthermore, any single sample measurement has almost no meaning as far as "good" or "bad".

A statistical application local to the integrated router could monitor a history of vital signs like raw Frame Error Count (FEC), corrected errors and downstream power. For example, on a per channel basis, a rolling database window could record averaged samples over a statistically significant period of time and show if the frame error count, translated to a frame error rate, is trending up indicating a problem on any channel. It could be useful to graph the table to show this trend visually. Better yet, the application can track the trend itself and on a threshold, send an alert (SNMP trap, TR-69 inform) informing the management system or customer care proactively. This technique could be extended to Wi-Fi, Ethernet, MoCA®, HomePNA® and other interface types in the system.

SUMMARY

We've stated that the integrated router is the best choice for hosting applications needing the properties described in the opening paragraphs. The always-on nature guarantees access *when* it's needed. Its connectivity to the internet guarantees access from *where* it's needed. And its intimacy to

all devices on the extended home network guarantee access to *what* is needed - simply, conveniently and at high quality. The example applications outlined reinforce this point of view.

M2M applications demand all the brain qualities the router can provide. They need to always be on and ready, connected through internet and provide on demand access to devices on the extended home network. These applications need a high degree of local abstraction and autonomy to hide complexities from the user experience and scale to the Cloud.

Personal Content applications are more valuable when the content can be accessed and exchanged from anywhere and anytime. The local autonomy and intimacy of the application with the router make configurations automatic and remote management seamless.

Advanced Home Network Discovery and Management applications take great advantage of the intimacy between the router and broadband modem systems, performing continual measurements and diagnostics not available or scalable from traditional management systems alone. This helps ensure the technological complexity of the networking environment doesn't subtract from the reliability and usability of the connection.

This is also a good time to circle back and thank our friend, performance. Thirst for greater performance has driven the silicon industry to higher densities making more processing power available to router applications in the form of faster CPUs and multiple cores. In older generations of silicon the desire may have been there for hosted applications on the router, but the processing platform was not. It's the brawn of the modern integrated router that has made the brain possible.

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