**2 Background**

Home networking has been a hot topic for several years. Thanks to the rapid development of electronics and computer science, home networking devices are becoming more affordable and more powerful than they ever were. It is now so common that a person would have several multimedia devices that can be connected to the network.

This chapter reviews the history of home networking development and compares five most popular home networking solutions. Section 2.1 presents an overview of current solutions of home networking that bridges these multimedia devices. Section 2.2 describes the technical details of five most popular solutions. Section 2.3 provides a comparison among these protocols and identifies the challenges that face home networking.

**2.1 Overview**

Early research [2] [3] [4] conducted on home networking mainly aimed to find out how home networking infrastructure can be built. The subjects of the research, including cable connection, wireless connection, optical connection etc, concern more about the physical layer of the home network. So far, it has turned out that the IEEE 802.11 protocol stack, among all others, is the most successful and widely deployed home networking infrastructure.

Nowadays, a typical scenario of home networking is that an IEEE 802.11 supportive wireless router connecting to a Ethernet cable or optical cable from the network operator creates a local network and other user devices simply join this network. The wireless Access Point(AP) employs the 802.11 b/g/n/ac protocol, utilizing the 2.4 GHz or 5 GHz frequency channels and providing a 100+ Mbps network connection, whose bandwidth is sufficient for transmitting the popular High Definition (1080p) videos.

In terms of network and application layer technologies, different device manufactures tend to choose their preferred multimedia-sharing protocols from the pool of protocols that have been evolving and developing for a long time.

Since late 1990s, UPnP protocol had been developed for home networking usage. At that time, XML was popular and widely used by different network applications. Under such background, UPnP was designed to fully make use of XML. UPnP is independent of media types and devices and it runs on the TCP/IP stack, thus it can be easily applied to modern network infrastructures.

In June 2003, Sony and several leading consumer electronic manufacturers established the Digital Living Network Alliance (DLNA), a nonprofit collaborative trade association. The DLNA standard is based on the widely used UPnP protocol but it added some restrictions on media formats and some compatibility requirements. A device hardware and software can be certified by DLNA organizations to prove that it can work with other devices that also passed this certification.

In 2010, Apple quit DLNA and developed its own multimedia home networking solution, known as AirPlay. By adding screen mirroring, authentication and Re- mote Audio Output Protocol(RAOP) music streaming, Apple tried to forge a more advanced home network sharing system, aiming to provide a unique user experience among Apple products. Apple’s solution indeed attracted people’s interest, and the user experience proved much better than that of other similar products in the market. With its improvement over the years, Apple’s solution has now been acknowledged as one of the most popular streaming solutions.

Two years later, Wi-Fi alliance released its Miracast technology, and participated in pushing new standard in wireless home networking. The Miracast uses the Wi-Fi direct technology and it does not require a wireless local network. Instead, a peer- to-peer connection is created between the sharing and receiving devices. After its release, some major software and hardware companies soon accepted this new standard. Google, for example integrated Miracast support into its Android operating system, and provided a screen-mirroring feature to other Miracast receivers.

The competition in home networking rages on over the years. In 2013, Google released a 35-dollar Dongle, using its Chromecast protocol, which makes it possible to watch YouTube and Netflix video directly on TV with such a dongle device. Lap- top and mobile devices with official YouTube App or Chrome browser can control the Dongle through the home local network. In this solution, the home networking is pushed to the cloud, since YouTube and Netflix content are directly downloaded from the Internet whereas the mobile device just acts as a controller for choosing the contents.

At the same time, in September 2013, Spotify, a startup music service company also took part in making its own home networking solution, called Spotify Connect. Spotify Connect provides an interface for users at home to access its huge music database, and directly browse and stream using its mobile application. Home net- working has again been pushed towards the cloud and Internet services in Spotify Connect.

Since so many companies would like to develop their own devices and even their own protocols, the market is a bit messy. Devices from different companies are not compatible with each other and users have to buy a different device in order to access different services like Netflix and Spotify, which are provided by different companies. This has created a big demand on a solution that can connect those devices at home and make them work together in a user friendly manner.

In response of this market need, our Streambels project has been initiated, aiming to fill the gap among different protocols and connect these different types of devices in the home networking environment.

**2.2 Available standards**

This section describes the most popular solutions for multimedia home networking. Section 2.2.1, 2.2.2, 2.2.3, 2.2.4 and 2.2.5 provide the detailed technical implementations and simple use scenarios of Universal Plug and Play, DLNA, AirPlay, DIAL and Miracast. Section 2.2.6 outlines other popular protocols proposed recently.

**2.2.1 Universal Plug and Play**

This section describes the Universal Plug and Play protocol stack and the UPnP Audio/Video device architecture which is more specifically targeted to multimedia home networking. Section 2.2.1.1 introduces the general UPnP device architecture. Section 2.2.1.2 presents the UPnP Audio/Video device architecture and a typical UPnP Audio/Video use scenario.

**2.2.1.1 UPnP device architecture**

Universal Plug and Play (UPnP) is a series of networking protocols defined to work together and seamlessly discover the presence of all devices in the network , establish- ing functional network services for data sharing, communications, and entertainment among these discovered devices.

In most UPnP scenarios, a control point controls the operation of one or more UPnP devices. The interaction usually occurs in isolation between control point and each device. It is the control point’s responsibility to coordinate the operation of each device and the individual devices do not really interact directly with each other.

The UPnP device architecture [5] is consisted of Addressing, Discovery, Description, Control, Eventing and Presentation.