IP-STB Solution Guide

TECHNOLOGY TREND

PRODUCT FOCUS

CASE STUDY
- SD STB with W5100
- HD PVR with W5300

www.wiznet.co.kr
STB Internet Connectivity Trend

Today, the Internet is the human life itself. People watch movies, listen to music, enjoy gaming and acquire any information through the Internet. The Internet function can be applied to any kind of devices. Especially, the production of IP based home electronic appliances is dramatically increasing, and the number is expected to reach about 300 million by 2012.

Every year, manufacturers release IP-based new appliances such as DTV (Digital TV), DVD, Cable & Satellite STBs, IP-TV, Internet Phone, and etc. Among these products, STB is playing the main role by leading the trend of digital convergence. In the past, STB just converts a TV signal and displays the contents on the television. After the STB is digitalized and Internet enabled, STB changes its contents to interactive shows and video on demanding IP-TV. STB is being developed to contents STB, Interactive STB and IP-TV. As of now, the STB is a powerful platform for providing Internet services.

STB products can be divided into two categories low-end and high-end. Contents STB or Interactive STB are considered as low-end, and Network PVR or IP-TV are grouped as high-end.

Just 2 or 3 years ago, the internet functionality was not considered for the low-end STB. However, with the change of market requirements, the internet functionality is widely spread into the low-end STB market. On the other hand, the main functions of high-end STBs focus on Internet services. The low-end STB occupies most of the world market shares especially in the economical and Standard Definition platform. This STB requires low bandwidth internet functions such as firmware downloading, PPV (Pay-per-

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<th>Category</th>
<th>Low-end STB</th>
<th>High-end STB</th>
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<tr>
<td>Product line</td>
<td>Contents STB, Interactive STB</td>
<td>Network PVR, IP-TV</td>
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<td>Main Ethernet function</td>
<td>Simple data (Text, image, Web page) transmission</td>
<td>Real time multimedia Streaming, IP broadcasting</td>
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<tr>
<td>Now Ethernet bandwidth</td>
<td>Normally, 2-5 Mbps</td>
<td>Normally, 10-15Mbps</td>
</tr>
<tr>
<td>Required Ethernet bandwidth</td>
<td>5Mbps</td>
<td>35-40Mbps</td>
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view), return path, and STB remote configuration. The Contents STB provides simple & text-based information such as the weather forecast, news, stock information through the Internet. Interactive STB does not only provide text-based information, but it can also provide interactive services such as home shopping, home banking, simple Video on Demand, or even e-mail. These functions are becoming standard services for the low-end STB.

Even though it sounds easy to retrieve simple text information from the Internet, the actual TCP/IP network implementation is quite complicated. There are 3 key factors which you have to consider: TCP/IP software Stack porting, TCP/IP stack license fee, and memory extension. In addition, the performance of the main CPU should be considered as well because TCP/IP process increases the overhead of the CPU. Under these considerations, the possibility to modify the existing H/W platform is high. Therefore, if user has to modify the H/W platform to implement even the simplest internet function, user would lose his product’s competitiveness. That’s a non-sense. If there is another solution to enable the Internet without changing the existing H/W platform, all problems can be solved at once. Here is the answer - Wiznet’s TCP/IP hardware chips. Since 10 years ago, Wiznet (www.wiznet.co.kr) has been providing hardware TCP/IP chip solution. The WS100 is mainly used for low-end STB, and our up-coming WS5200 is a cost effective and simplified version of WS100.
In the high-end STB sector, network PVR and IP-TV are the main applications. They mainly provide HD (High Definition) video services. For the network PVR case, this system provides internet real-time VOD, recording, play-back and editing. IP-TV, originally developed from PVR, provides limitless Internet services including IP-based real time broadcasts and multi-media contents. The concept of IP-TV service is described below.

Both Network-PVR and IP-TV basically support Internet real time streaming. To get the best quality out of real-time streaming and other Internet functions, high end STB should have enough performance to operate the following smoothly.
1. Multicasting,
2. Contents Uploading,
3. Peer to Peer communication
4. Widget function
These functions absolutely require high performance CPU and high internet bandwidth. Recently, HD videos are being developed into 3D based contents.
With large amount of data being processed by the TCP/IP network, the CPU performance is affected due to the CPU overhead of TCP/IP processes. This overhead can be overcome by increasing the performance of the CPU. However, as far as software TCP/IP is used, there is still a limitation in processing TCP/IP data from the Internet. Consequently, the system is often in an unstable state which leads to system failure. Therefore, for high-end STB, the Ethernet solution must guarantee high bandwidth and performance to get product stability and reliability.

By reflecting this system trend and requirement, WIZnet’s W5300 has been specifically designed to solve the limitations in existing software TCP/IP stack system.

WIZnet’s TCP/IP technology is strong against Internet virus, hacking or DDoS. These attacks happen generally though common Socket managed by the Operating System. The hardwired TCP/IP architecture automatically discards any abnormal packets which are infected with virus or distorted by hacking.

WIZnet solution basically, provides 4~8 sockets which are enough to implement whatever internet functions. User can easily manage all sockets as he desires.

If hacker doesn’t know the socket number used by the application, it is much difficult to attack the user’s device. Of course, when user wants to use more sockets for his specifications, WIZnet chip can provide more sockets as well.

Recently, the WiFi solution is often adopted in both low-end and high-end products for easy installations and simple management. Wireless adaptor cards [such as SDIO, USB, Mini-PCI types] are impractical in applying to STB. These wireless devices with limited MCU interfaces only operate as a client, and rely on the drivers in OS.

In order to solve these existing problems with wireless adaptor cards, WIZnet has developed WIZ610Wi which supports 802.11b/g. An upgraded version with 802.11bgn support will be released during this year.

In this digital convergence era, the STB market requirements changes day by day. Every manufactures in the world are trying to follow with the latest trend to get the upper hand of the STB market. To keep up with this movement, WIZnet is continuously helping out STB companies to adopt Ethernet solutions.

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Hardware TCP/IP Core Technology

Legacy OS-based System

TCP Offloaded System

Application Program

TCP/UDP
IP, ARP, ICMP, IGMP
Driver Program
MAC
PHY

Easy-to-use
Simple system composition
MCU offloading
Low power consumption
Line speed protocol processing
Reliability & Stablity

IOffload™ System

![Bar graph comparison between OS based system and ioffload system](image)

- TCP/IP
- Driver
- Bufmgmt
- Copy
- User Application

Now, user’s system is free to do more & more
W5100 - Simple and Easy Embedded Internet Connectivity Solution

W5100 is a perfect fit for the applications requiring easy and simple Ethernet implementation. Especially in the low-end STB products, the main Ethernet functions are quite simple - providing simple & text-based information, return path channel, firmware downloading, and etc. W5100 will enable all those functionalities without changing existing hardware platform.

W5100 includes fully hardwired, market-proven TCP/IP stack and Integrated Ethernet MAC & PHY. Without consideration of handling Ethernet controller, you can add Internet connectivity to your device just by simple socket programming.

**KEY FEATURES**

- Support Hardwired TCP/IP Protocols: TCP, UDP, ICMP, IPv4, ARP, IGMPv2
- Supports 4 independent sockets simultaneously
- Internal 16Kbytes memory for data communication
- 10BaseT/100BaseTX Ethernet PHY embedded
- Internal 16Kbytes Memory for Tx/Rx Buffers
- Support Serial Peripheral Interface (SPI) MODE 0, 3
- 3.3V operation with 5V I/O signal tolerance
- Small 80 Pin LQFP Lead-Free Package

W5300 - High Performance Embedded Internet Connectivity Solution

W5300 has been designed to guarantee high Ethernet bandwidth and performance in the high-end STB products. By using W5300 you can get the best quality out of real-time streaming of HD video images. In addition, any interactive services such as e-commerce, two-way education, on-line game, and etc can be implemented successfully.

W5300 is a 0.18µm CMOS technology single chip into which 10/100 Ethernet controller, MAC, and high performance fully-hardwired TCP/IP are integrated.

**KEY FEATURES**

- High network performance: Up to 50Mbps
- Supports hardwired TCP/IP protocols: TCP, UDP, ICMP, IPv4, ARP, IGMPv2, PPPoE, Ethernet
- Supports 8 independent SUCKEs simultaneously
- Supports hybrid TCP/IP stack
- Internal 128Kbytes memory for data communication
- More flexible allocation internal TX/RX memory according to application throughput
- Supports memory-to-memory DMA (only 16bit Data bus width & slave model)
- Embedded 10BaseT/100BaseTX Ethernet PHY
- Supports 16/8 bit data bus width
- 3.3V operation with 5V I/O signal tolerance
- 100LQFP 14x14 Lead-Free Package
W7100

The W7100 is an one chip solution which includes 8051 compatible CPU core and hardwired TCP/IP core. The CPU core of W7100 is a high performance, speed optimized 8-bit embedded controller to be operated with on-chip memories at high speed.

The TCP/IP core is a market-proven hardwired TCP/IP stack with an integrated Ethernet MAC & PHY. The W7100 comes with a 32bytes internal buffer for data transmission.

- Fully compatible with industrial standard 8051
- Internal 64Kbytes Data Memory [RAM]
- Internal 64KBytes SRAM
- Internal 2KBytes boot ROM
- Internal 128 Bytes embedded data Flash memory
- Hardwired TCP/IP Protocols : TCP, UDP, ICMP, IPv4, IGMP, PPPoE, Ethernet
- 10BaseT/ 100BaseTX Ethernet PHY Embedded
- Support 8 hardware sockets
- 100 LQFP Lead-Free Package

W5200

W5200 is a compact-sized 10/100 Ethernet controller to be released on December, 2009. W5200 has been designed for the embedded devices where easy implementation, system stability, high performance and competitive price are required. W5200 will enable even small device to have Internet connectivity without OS.

W5200 includes fully hardwired, market-proven TCP/IP stack and integrated Ethernet MAC & PHY. No need of consideration for implementing Ethernet, but simple socket programming is required.

- Hardwired TCP/IP Protocols : TCP, UDP, ICMP, IPv4, IGMP, Ethernet
- 10BaseT/100BaseTX Ethernet PHY Embedded
- Support 8 hardware sockets
- Internal 32Kbytes Memory for Tx/Rx Buffer
- Support Indirect BUS and SPI Interface
- Support Power down mode
- 48 LQFN Lead-Free Package

Coming Soon
CASE STUDY

SD STB with W5100

Introduction of KAON and New Project
KAON media is the digital multi-media company which was established in 2001 by the most experienced specialists in the digital set-top box field. To meet the needs of the STB industry, KAON has teamed up with CAS (conditional access system) companies such as CONAX and NDS to launch a variety of high-end products based on middleware platforms.
In February of 2009, KAON started developing a “Free to Air” STB targeting operators in the Vietnam market. In this new development, the W5100 is used to provide the Ethernet functionality. In this article, we will introduce how the WiZnet solution is applied and used in the set top box application.

Main CPU and WiZnet
NEC’s EMMA2SL/P was selected for providing SD (Standard Definition) based video service.
Since EMMA2SL/P does not come with the Ethernet MAC & PHY, an external Ethernet solution is required. The WiZnet’s W5100 is a perfect fit for this purpose since it is easy to develop and use.
In this design, the EMMA MCU uses the external memory bus to communicate with the W5100.

Ethernet in STB Trend
In this section, we will consider the reason why KAON decided to add Ethernet even though the main CPU does not have an onboard Ethernet MAC/PHY. In the existing STB operator’s market, the Return Path [a payment system about some contents] has mostly been processed by the cable modem, PSTN or GSM. In case of using PSTN, the modem is the only method for the Return Path Channel which requires an additional part to be installed with main STB. To the service provider, this modem adds costs to the product which increases the total investment. By adopting the “Return Path through Ethernet” solution, the service provider can save money, and provide various services by Ethernet.

KAON and WiZnet in 2007
In 2007, WiZnet and KAON developed “SKY Life MBS STB” by using W3150A. With the use of a 2 port switching PHY chip and W3150A, the STB can simultaneously access Wide Area Network (WAN) and Local Area Network (LAN). Prior to the W3150A design, KAON used the software TCP/IP stack solution which required license fees. In addition to the cost increase, KAON was struggling to port the software stack which required in-depth TCP/IP knowledge. With WiZnet’s hardwired TCP/IP solution, only socket programming knowledge is required to operate the Ethernet and there is no license fee. Since WiZnet’s chipset manages the bottom OSI layers from the Physical layer up to the Transport Layer, the developers only have to worry about the application layer. Because WiZnet’s solution offers many advantages over software stack solutions, KAON and most of the Korean STB manufacturers adopted our solution.

WiZnet H/W Interface
When this project started back in February of 2009, WiZnet and KAON reviewed the hardware specifications and requirements. WiZnet’s W5100 offers 3 different interfaces (direct, indirect, SPI) to connect with the MCU. Considering the “Return Path Channel” carries important data such as payments, a robust Ethernet network is required for this type of system. The final design was based on the direct bus interface. Although KAON designed the hardware schematics, WiZnet checked and approved the design in order to minimize any errors or bugs.
As shown in the below schematic, the W5100 pins of /CS, /RD, /WR, 8bit data and 14bit address are connected to EMMA2SL/P by using external SDR/DDR extension memory interfaces.
**SD STB with W5100 (cont’d)**

**WiZnet S/W Porting**
After finishing the first board in March, software porting and debugging are started. The W5100 porting process is shown below.

**W5100 Device Drive Porting**
- W5100 Register Setting / Socket function Porting [ANSI-C]
- IP, Subnet, Gateway / Memory Size / Interrupt Setting
- Ping test: H/W and S/W Debugging

However, this network performance does not meet KAON’s requirements. After checking the firmware structure, WiZnet provides the following 3 advices to improve the network performance:

1. R/W active interval delay
2. Access periods
3. Ethernet Task modification: task_delay

After modifying the firmware by following advices above, KAON’s device was able to achieve a throughput of 7.7Mbps (Full duplex: 14~15 Mbps)

**Finalizing the Project**
The development project was finished in May, 2009, and moved to mass production phase. In the near future, the STB market in Vietnam, India and other Asian countries will expand greatly. The SD based STB for these markets is expected to increase as well. By applying WiZnet solution, Ethernet can be easily implemented by saving development time and cost. The KAON engineers commented on WiZnet’s products, “We are satisfying with its easy setup and use”.

**Optimization**
During the first loopback test, the network performance was around 0.8147 – 0.8361Mbps.
After checking KAON’s device driver, the socket memory was increased from 2Kbyte to 4Kbyte. The network performance was improved to 1.4110-1.4244Mbps.

**KAON**

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**CASE STUDY**

**HD PVR with W5300**

**Introduction of HDT and new Project**

HDT (Hyundai Digital Technology) is a Korean STB company who mainly develops and produces digital satellite, digital cable, PVR, IPTV and etc. Ever since established in 1998, HDT has grown from 1 million US dollars to 100 million US dollars in sales. With the rise of Asian markets, Korean STB manufacturers are entering new markets in Vietnam, India, and etc. to find new opportunities. HDT started to develop a HD PVR model which is targeted to service providers in India. In January of 2009, HDT started their HD PVR hardware design. In their new design, they have used STi7101 by STMicroelectronics as their main processor and W5300 by WIZnet as their network controller.

**STB Main CPU and Ethernet Controller**

The main processor chipsets from Broadcom, STMicroelectronics, or Sigma Designs are mainly used for HD based STB in Korea. HDT selected STMicroelectronics’ STi7101 for this project because STi7101 is a high performance HD set-top box and DVD decoder chip. This chipset includes both MPEG 2 and H.264 video decoders, and 100Base T Ethernet controller with integrated MAC and MII/RMII interface for external PHY.

The Ethernet controller of this new product is used to communicate with a middleware and add some Internet services. WIZnet’s W5300 was adopted for the Ethernet functions.

As shown in the specification, STi7101 already includes the integrated MAC and MII/RMII interface. Therefore, the network can be implemented just by adding an external PHY chip. In HDT’s point of view, the W5300’s additional MAC overlaps the onboard MAC in STi7101. However, the main reason why HDT chose WIZnet’s solution is the network performance. With the software TCP/IP stack, resource is shared between the CPU and networking. When there is a large amount of data to be processed by the network, the CPU overhead is increased as well. This CPU overhead degrades the overall system stability and affects the main PVR functions such as Video/Audio Output and HDD recording. WIZnet chipset minimizes CPU overhead by processing all the under layers of TCP/IP. As a result, the CPU just needs to write/read data from the W5300 chipset in order to use the Ethernet functionality.

**WIZnet H/W Interface**

As it was the first time that HDT selected WIZnet, they approached more carefully when started the hardware design. According to the reference hardware schematic provided by WIZnet, the initial design was started. Considering better network performance, direct bus was used for CPU interface. All network part was checked and confirmed by WIZnet RnD.

**WIZnet S/W Porting & H/W Debugging**

The software was implemented according to the procedure as suggested by WIZnet.

1) Device Drive Porting
2) Ping Test
3) Loopback [TCP/UDP Test]
4) Application [DHCP etc...]

After the device driver porting was completed, simple test was performed to check the network configurations. After writing to the IP, gateway, subnet mask registers, data verification should be performed. In HDT’s initial testing, there were differences in the data being written and read from the registers. After reviewing the source code and hardware schematics, we have found out that the W5300 was not properly connected to the STi7101. Ping test and loopback test were operating after fixing the interface connection. By using the DHCP reference source code and application note, HDT engineers implemented the DHCP function without any problem.
Optimization by Using Hybrid Architecture of W5300

After the development of Ethernet via hardware stack was completed, HDT started to connect W5300 to the middleware which is operated in the upper layer of WiZnet. When we received the full specifications of the middleware, W5300’s hardware channels can not process the middleware data because the middleware was specially designed to use with a software TCP/IP stack. The middleware requires raw Ethernet packets. However, W5300’s hardware channel processes all TCP/IP by removing the frame and header. Then, the raw data is provided to the host CPU. Due to the incompatible format of Middleware and WiZnet’s hardware channel, the Hybrid architecture of W5300 was used to overcome this problem. With this architecture, the STB can utilize the hardware stack for application use while leaving the software stack for middleware use.

Basically, W5300 provides 8 sockets to process Ethernet data through TCP/IP hardwired core. However, if we configure the first channel (socket #0) as Mac-Raw mode, the socket #0 operates as like MAC/PHY chips.

By opening this Mac-Raw channel, we could establish the connection between W5300 and the middleware, and add the functions to be processed by the middleware.

Finalizing the Project

All development and testing were finished in July, 2009. WiZnet provides reliability materials such as RoHS, SVHC, temperature testing report, and etc when this model moved to mass production.

WiZnet chipset has been designed to support both of software and hardware TCP/IP stack. With this Hybrid architecture, WiZnet can cope with any requirement from STB middleware or Embedded OS system more flexibly.

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Enjoy your **Creativity** at **iMCU Design Contest** on **WIZwiki.net**

iMCU W7100 is an Internet MCU integrating HW TCP/IP core with 8051processor