Standardization Activities of Home Networking Technologies and Backbone Solutions

Ho-In Jeon
hijeon@mail.kyungwon.ac.kr, hoinjeon@netsgo.com

Associate Professor
Department of Electronic Engineering
Kyung-Won University

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Bandwidth Requirements for Data

• Voice and Audio data
  - Uncompressed PCM: 64 Kbps
  - QCELP: 13 Kbps
  - G.726 (CS-ACELP): 8 Kbps
  - G.723.1: 4.8 Kbps, or 5.6 Kbps for VoIP
  - Audio Data: 352.8 Kbps

• Image Data
  - Uncompressed SDTV: 221 Mbps
  - Uncompressed HDTV: 1.3 Gbps
  - Compressed SDTV (MPEG-2): 4 Mbps ~ 8 Mbps
  - Compressed HDTV (MPEG-2): 20 Mbps

• QoS is crucial for both data and multimedia signals.
Standardization Meetings Attended (1/2)

1. 1999. 07. 13 - 07. 16 1999 1394TA 3Q (San Mateo, CA)
2. 1999. 10. 19 - 10. 22 1999 1394TA 4Q (Las Vegas, NV)
3. 2000. 01. 18 - 01. 21 2000 1394TA 1Q (Honolulu, Hawaii)
4. 2000. 07. 24 - 10. 17 2000 1394TA 3Q (Berkeley, CA)
5. 2000. 10. 24 - 10. 27 2000 1394TA 4Q (Seattle, WA)
6. 2001. 01. 06 - 01. 07 CEA/EIA R7.4, R7.5 (Las Vegas, NV)
7. 2001. 01. 15 - 01. 18 2001 1394TA 1Q (Hawaii, Big Island)
8. 2001. 04. 03 - 04. 06 2001 1394TA 2Q (Singapore)
9. 2001. 05. 14 - 05. 18 CEA/EIA R7.4, R7.5 (Indianapolis)
10. 2001. 06. 04 - 06. 08 ISO/IEC JTC1 SC25 WG1 (London)
11. 2001. 07. 23 - 07. 26 2001 1394TA 3Q (Vancouver, Canada)
12. 2001. 08. 06 - 08. 07 UPnP Forum (Seattle, WA)

Standardization Meetings Attended (2/2)

13. 2001. 11. 01 - 11.16 IEEE802 Plenary, (Austin, TX)
14. 2001. 11. 27 - 11.29 UPnP Forum (Seattle, WA)
15. 2002. 01. 15 - 01.17 2002 1394TA 1Q (Hawaii, Big Island)
16. 2002. 01. 20 - 03.25 IEEE802.11, 15 Interim, (Dallas, TX)
17. 2002. 02. 25 - 03.01 CEA/EIA R7.4, R7.5 (Charleston, SC)
18. 2002. 03. 06 - 03.07 HAVi Meeting (Denver, CO)
19. 2002. 03. 10 - 03.15 IEEE802 Plenary Mt. (St. Louis, MO)
20. 2002. 05. 01 - 05. 03 2002 1394TA 2Q (Barcelona, Spain)
21. 2002. 05. 02 - 05. 07 ITU-R JTG 4/7/8/9 (Geneva, Swiss)
22. 2002. 05. 13 - 05. 17 IEEE802.11, 15 Interim, Sydney, Aus.
23. 2002. 07. 08 - 07. 12 IEEE802 Plenary, Vancouver, Canada
Positions in Charge

1. 1394 Forum 의장: 1999
2. 3D TV 추진협의회 의장: 2000
3. 산업자원부 컴퓨터 산업기술모드맵 전문위원회 위원장: 2001
4. 대한전자공학회 회로 및 시스템 연구회 위원장: 2002
5. ISO/IEC JTC1 SC25 전문위원회 위원장: 2002
6. 정통부 초고속 무선 LAN 포럼 표준분과위원회 위원장: 2002
7. ISO/IEC JTC1 SC6 전문위원회 위원: 2002
8. Home Station 표준화 Forum 전문위원회 위원장: 2002

Key Applications of Home Networking

- Broadband Internet Access Sharing
- Digital Video Distribution
- Multi-Line Telephony
- Multimedia Delivery
- Remote Access
- Multi-Player Games
- Peripheral Sharing
- Data and File Sharing
- Home Automation
Requirements for Home Networking Systems

- Provision of **Plug and Play** and **Low Cost** Devices
- Guaranteed **Security and Privacy**
- Support for **Heterogeneous Network Topologies**
- **High-Speed Data Transmission Capability** between Devices.
- Common Interfaces between Various Devices
- Mobility of Devices and thus Reconfiguration Supported.
- **No New Wire Solutions**
  - Human Interface Considered
  - Capability of Integrating Broadcasting and Communications
- **Support for various types of QoS!**

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Home Networking Application Utopia

- Simple way to access devices across **multiple networks** independent of any one Home Networking technology.
- Applications care more about **AV services** than device management.
- Applications could benefit from an architecture which exposes AV services in ways that **abstract device controls.**
- **Collective interfaces** free of HN Architecture features.
- Separation of services and devices.
Issues With Devices

- Things to ponder when controlling devices across heterogeneous networks
  - Addressing
  - Discovery
  - Service Disclosures
  - Controls
  - Naming Conventions
  - Resource Management
  - Presentation

Bridges vs. Superstructure

- Abstraction Framework
  - More flexible
    - solves issues across multiple technologies
  - Configurable
    - Inclusive, exclusive, etc
  - Includes features beyond a bridge
    - Resource Mgr, Persistence, etc

- Bridges
  - Convert one protocol to another
    - Less flexible
  - Less expandable
Home Networking Model

- Backbone
- Network

• Access
  • Network
  • Access
  • Network

Gateway #1
Bridge #1
End Device
Access-Component Interface
Gateway #3
Component Network
(e.g. IEEE1394)
End Device
Access-Component Interface

Gateway #2
Bridge #2
End Device
End Device
Component Network
(e.g. PLC)
Access-Component Interface
Gateway #4

HomePNA V1.0 for Backbone Solutions

• Adopted HomeRun Technology Developed by Tut Systems

• Characteristics
  • Transmission Speed: 1 Mbps
  • Transmission Distance: 500 feet (150 m)
  • Modulation: Time Modulation Line Coding Method
  • Bandwidth: 5.5 - 9.5 MHz
  • Center Frequency: 7.5 MHz
  • MAC: IEEE 802.3 CSMA/CD
  • Supports up to 25 Nodes
  • Uses RJ11 Telephone Jack
  • Extra Wiring, Hubs, Splitters, Filters, Terminations not required
  • FCC Part 15 class B and Part 68 Compliant
  • True plug-and-play operation
  • Low Cost: Less than $50/Node
HomePNA V2.0 for Backbone Solutions

- Adopted Epigram’s Technology. Commercialized by Broadcom.
- Characteristics
  - Transmission Speed: 4 - 32 Mbps Data Rate, Nominal 10Mbps
  - Transmission Distance: 1,000 feet (300 m)
  - Modulation: 4 Mbaud QAM, 2 Mbaud FDQAM (Frequency Diverse QAM)
  - Carrier Frequency: 7 MHz
  - Bandwidth: 4.75 - 9.25 MHz
  - MAC: IEEE 802.3 CSMA/CD
  - Compatible with HomePNA 1.0 Specification, POTS, V.90, ISDN, G.lite
  - Built-in QoS protocols
  - Low Cost: Less than $100/Node
- Issues
  - Spectral incompatibility with VDSL (120 KHz - 30 MHz)

HomePNA V3.0 for Backbone Solutions

- Under developments and Standardization Processes.
- Characteristics
  - Transmission Speed: 100Mbps
  - Used Band: 13 ~ 28 MHz
  - Transmission Distance: 1,000 feet (300 m)
  - Modulation: OFDM
  - Carrier Frequency: 20.5 MHz
  - Bandwidth: 15 MHz
  - Number of Subcarriers: 256
  - Channel Analysis using Training Sequence in the Initialization Process
  - MAC: IEEE 802.3 CSMA/CD
- Issues
  - Korean Home does not provide full connectivity all over the premise.
PLC for Backbone Solutions

- Advantages
  - Goes to at least three walls in every room in the house
  - The ultimate “No new wires” solution
  - All devices requiring wall power (almost all) need no additional external connection

- Disadvantages
  - **Noise profile** on the power line (Dimmers, SMPS, Power line intercoms, Universal series wound motors) results in fading channel, needing **FEC**, and thus losing **Bandwidth**.
  - Power lines are designed for delivering power not data
    - High Attenuation (Voltage dividers, Phase coupling loss)
    - Signal distortion
  - Data privacy
  - **Interoperability**
  - Interface means are still expensive

PLC Core Technologies

- Transmission Speed
  - Low: 60 bps ~ 10 kbps
  - Medium: 10 kbps ~ 1 Mbps
  - High: 1 Mbps ~ 10 Mbps

<table>
<thead>
<tr>
<th>Front End Skill</th>
<th>Channel adaptation(Coupling, Adaptive Filter) Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Coding</td>
<td>Convolution Code, Reed Solomon Code(iAd)</td>
</tr>
<tr>
<td></td>
<td>OFDM, Carrier Chirp, CRC(Intellon: Echelon)</td>
</tr>
<tr>
<td></td>
<td>Optimized FEC(ITRAN)</td>
</tr>
<tr>
<td></td>
<td>RS code(Keyin)</td>
</tr>
<tr>
<td></td>
<td>Zero cross clocked carrier(X:10)</td>
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<tr>
<td></td>
<td>ZCCC, Carrier Chirp, Convolution, Viterbi(Planet)</td>
</tr>
<tr>
<td>MODEM</td>
<td>Chirped-SS, DS-SS, DS-CDMA, OFDM</td>
</tr>
<tr>
<td>MAC</td>
<td>CSMA/CD, Token Passing(A.N)</td>
</tr>
</tbody>
</table>
### IEEE1394 Standards Specifications

- **IEEE1394-1995**
  - Speed: 100, 200, 400 Mbps
  - Maximum Distance between Nodes: 4.5 ~ 10 m
  - Maximum Number of Nodes: 63
  - No loops allowed.

  - Connection Debounce.
  - Cable Arbitration Enhancements.
  - Performance Optimization via PHY "Pinging."
  - Priority Arbitration.
  - Port Disable, Suspend and Resume.

### Recent and Future Standards of IEEE1394

- **P1394b**: Finalized in 4Q2000.
  - Speed: 800, 1600, 3200 Mbps
  - Maximum distance between nodes: 100 ~ 800 m
  - Extended PHY/LINK interfaces using 8-bit parallel bus to support higher data rate.
  - Loop is allowed by loop-breaking mechanism.

- **IEEE1394.1**
  - Adopts bridging issues for having more than 63 devices.
  - Wireless 1394 is the application of 1394.1
  - Standardization finalized in 1Q2001.

- **SerialPlus (IEEE2100)**
  - Future standard using coherence of SCI (Scalable Coherent Interface) and isochronous transmission of IEEE1394.
IEEE1394 Addressing (IEEE1212)

Example: 0xFF FE 0x3F 0xFFFE 0x000200
10 bits 6 bits 20 bits 28 bits

=all cycle timer registers on local bus

IEEE1394 Configuration Process

- Bus Reset
- Tree Identification
- Self Identification
- Cycle Master Starts
- IRM Identified

Occurs when reconfiguration needed, such as live insertion & new cycle master.
Identifies Root
Numbers the nodes
Communicates Speed Info
Generates Cycle Start Packets
Prior Isochronous Transfer Resume
Identifies which node contains Isochronous Resource Manager

Bus Management Initialization
IEEE1394 Bus Timing

- Isochronous (short) gaps
- Asynchronous (long) gaps

Cycle #m-1 → packet A → cycle start data = x → ch J → ch L → ... → ch N → packet B → cycle #m

Start delay = x

Nominal cycle period = 125 usec

Cycle #m → packet C → cycle #m+1

Start delay = y

Cycle synch

IEEE1394.1 Bridge Concepts

- A bridge is a device that connects two separate IEEE1394 buses, facilitating the communications between devices that are not on the same bus.

- Why do we need Bridge?
  - We need more than 63 devices.
  - We need to isolate bus resets.
  - We need to isolate bus bandwidth utilizations.
  - We need to limit gap counts.
  - We need to connect diverse media, e.g., wired 1394 and wireless.
Parts and Construction of a Bridge

- Left Portal’s
- Right Portal’s
- 1394Bus
- 1394Bus

Left Portal
Right Portal

Could be Wireless

- A bridge consists of two portals which connect two IEEE1394 buses through a fabric.
- The fabric of the switch may anything, long or short.
- The two portals may share power supply or not.

Bridges change IEEE1394 assumptions

- Remote transaction timeouts
  - Longer than local bus split timeout
  - Transaction is routed through multiple busses
  - Latency through switch fabric may be long (wireless!)

- Remote addressing errors
  - Bus ID invalid
  - Path (temporarily) unavailable

- Cannot rely upon bus reset for synchronization
- Revalidate virtual IDs upon signal from bridge
**Bluetooth as a Backbone**

- Forget Plug and Play - just Play
- 1Mbps (Sync), 723.2Kbps (Async)
- 2.4GHz ISM band
- 3 voice channels
- 8 participants in a piconet
- Crucial component for the wireless world!
- Simple cable replacement

**Piconet and Scatternet of Bluetooth**

**Piconet**

**Scatternet:** not defined yet in BT1.1
**IEEE802.11a MAC SAP Primitives**

- **MLME-GET.request**
- **MLME-GET.confirm**
- **MLME-RESET.request**
- **MLME-RESET.confirm**
- **MLME-SCAN.request**
- **MLME-SCAN.confirm**
- **MLME-START.request**
- **MLME-START.confirm**
- **MLME-DEAUTHENTICATE.request**
- **MLME-DEAUTHENTICATE.confirm**
- **MLME-ASSOCIATE.request**
- **MLME-ASSOCIATE.confirm**
- **MLME-DISASSOCIATE.request**
- **MLME-DISASSOCIATE.confirm**

**Hidden Node Problem**

- **CTS Range**
- **RTS Range**
- **Destination**
- **Source**
- **A**
- **B**
- **C**
- **Others**
**Security Services of IEEE 802.11**

- Provided by the authentication (802.1x) and WEP (Wired Equivalent Privacy) mechanism.
- Limited to station-to-station data exchange based on the encryption of MSDU.
- WEP is located in the MAC sublayer.
- Security services provided are...
  - Confidentiality
  - Authentication, and
  - Access Control in conjunction with Layer Management.
**Standard Activities on Wireless LAN**

- **IEEE802.11** Wireless LAN.
  - 802.11b: Supports 11 Mbps at 2.4 GHz with FH/DSSS/IR
  - 802.11a: Supports 54 Mbps at 5GHz with OFDM
  - 802.11e: Enhancement of QoS.
  - 802.11f: Inter AP Protocol
  - 802.11g: Supports 54 Mbps at 2.4 GHz with OFDM
  - 802.11h: Adoption of TPC and DFS to avoid Interference
  - 802.11i: Enhancement of Security
  - 802.11 5GSG: Harmonization of 5GHz Range
  - 902.11 WNG: Wireless LAN Next Generation

- **ETSI BRAN** HiperLAN 2

- **WECA (Wireless Ethernet Compatibility Alliance)** Wi-Fi
Standard Activities on Wireless PAN & MAN

- IEEE802.15 Wireless PAN
  - 802.15.1: Bluetooth
  - 802.15.2: Coexistence
  - 802.15.3: High Speed at 54 Mbps with Security
  - 802.15.4: Low Price with Low Speed at 300Kbps
  - 802.15SG3a: UWB ( Ultra Wide Band)

- 802.16 Wireless MAN
  - 802.16: Broadband Wireless Access Using 11~60 GHz
  - 802.16a: Broadband Wireless Access Using 2~11 GHz

- ETSI BRAN HiperAccess

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TGe for MAC Layer Enhancement of QoS

- PAR approved in Nov. 1999.

- The goal is to provide a certain level of QoS for real-time data.
  - Voice: ADPCM: 20msec.
  - MPEG Video: 3Mbps, MPEG2, IEEE1394.
  - TCP/IP Ethernet data streams at 10 Mbps.
  - Minimize latency, delay variations, and Max. throughput.
  - Define traffic model for both Ad-Hoc and infrastructure.
  - Static and dynamic loading and handoffs between BSSs.

- Draft 3.1 is available which has been completed in 2001.
New Concepts Adopted in TGe 2.0 for QoS

- Contention Free Burst (CFB)
- Controlled Contention (CC)
- Controlled Access Period (CAP)
- Hybrid Coordination Function (HCF) and Hybrid Coordinator (HC)
- QoS AP (QAP) and QoS BSS (QBSS)
- Traffic Category (TC) and Traffic ID (TID)
- Traffic Specification (TSPEC)
- Traffic Stream (TS)
- Transmission Opportunity (TXOP)
- Reservation Request (RR)
- Burst Ack.
- Mobility Types: QBSS Transition

Some Issues Being Clarified in TGe

- Bridge Portals (Dead)
- EDCF (Alive and Ongoing)
- Controlled Contention and Reservation Request (Alive)
- QoS Control Field (Alive and Ongoing)
- Side Traffic Setup and Signalling (Alive)
- HCF Polling (Alive and Ongoing)
- Burst Ack. and FEC Policy (Alive and Ongoing)
- QoS in IBSS (Dead)
- Overlapping BSS mitigation (Dead)
- AP Mobility (Accepted and finalized by TGe)
EDCF Timing Relationships for 802.11e

D1 = aRDFDelay + aRTxPCLPDelay (Starts at the end of the last symbol of a frame on the medium.)
D2 = aAirPropagationTime
Rx/Tx = aRxtxTurnaroundTime (Starts when MAC issues the PHYTXSTART.request.) < 5 μsec
M1 = M2 = aMACProcessingDelay < 2 μsec
CCAdv = aCCA1ime < 15 μsec (11b) 5.8 μsec (15.3)

802.11e MAC Frame Format

Bits: 4 12
Octet: 2 2 6 6 2 6 2 n 4
ID 1 2 3 Ctrl 4 Control

MAC Header

Bits: 2 2 4 1 1 1 1 1 1 1 1 1
**Overview of IEEE802.15.3**

- The IEEE P802.15.3 High Rate (HR) Task Group (TG3) for Wireless Personal Area Networks (WPANs™) is chartered to draft and publish a new standard for high-rate (20Mbit/s or greater) WPANs™.

- Besides a high data rate, the new standard will provide for low power, low cost solutions addressing the needs of portable consumer digital imaging and multimedia applications.

**PHY & MAC Features of IEEE802.15.3**

- Data Rates: 11, 22, 33, 44, & 55 Mbps.
- Quality of Service isochronous protocol
- Ad hoc peer-to-peer networking
- Security
- Low power consumption
- Low cost
- Designed to meet the demanding requirements of portable consumer imaging and multimedia applications.
Devices Covered by IEEE802.15.3

- Those that are carried, worn, or located near body.
- Networked Computers.
- Personal Digital Assistants (PDAs)
- Handheld Personal Computers (HPCs)
- Printers.
- Digital Imaging Systems.
- Microphones.
- Speakers.
- Headsets.
- Bar code Readers.
- Sensors.
- Displays.
- Pagers.
- Cellular & Personal Communications Service (PCS) phones.

Characteristics of PHY's of IEEE802.15.3

- The medium has neither absolute nor readily observable boundaries outside of which devices with conformant PHY transceivers are known to be unable to receive network frames.
- The PHY is unprotected from outside signals.
- The DEVs communicate over a significantly less reliable medium than wired PHYs.
- The WPAN has a dynamic topology.
- WPANs lack full connectivity, and therefore the assumption normally made that every WPAN device is able to hear every other WPAN device is invalid. The implication is that some DEVs would be "hidden" from others in the piconet.
- The medium has time-varying and asymmetric link properties.
IEEE802.15.3 MAC Functionalities

- Allow DEVs to form and terminate PANs
- Transport data between DEVs
- Authenticate DEVs with each other
- Allow DEVs (including the PNC) to minimize power requirements and still maintain the piconet.
- A procedure for the PNC to pass coordination to another DEV in the WPAN.
- A procedure to establish a child piconet. A child piconet is a sub-piconet that is linked to the parent piconet through its PNC which is a member of the parent piconet.
- A procedure to establish a neighbor piconet which is a sub-piconet that is disjoint from the parent piconet. The PNC of the neighbor piconet is not a member of the parent piconet.
- The data transport supports multiple quality of service (QoS) levels with optional privacy.

802.15.3 Piconet Superframe

<table>
<thead>
<tr>
<th>Beacon</th>
<th>CAP</th>
<th>CFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command</td>
<td>Data</td>
<td>GTS N-1</td>
</tr>
<tr>
<td>MTS 1</td>
<td>MTS 2</td>
<td>GTS 1</td>
</tr>
</tbody>
</table>

- Beacon
- Contention Access Period (CAP)
  - Uses CSMA/CA
  - Streamless data exchanges and commands are transmitted during this period.
- Contention Free Period (CFP).
  - This is composed of data streams, either synchronous or isochronous, with quality of service provisions
IEEE 802.15.3 General Frame Format

Octet: 2 2 1 1 2 2 2 Variable 0-4

Frame Control PNID Destination Address(DA) Source Address(SA) Stream Control Sequence Number HCS Frame Body FCS

MAC Header

DATA

B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B15

Protocol Version Ack Policy Frame Type Pad Octet Frag-Start Frag-End Retry Del-Ack Request Reserved SEC Repeater

Bits: 2 2 3 1 1 1 1 1 1 1

Key Features of 802.11e QoS Baseline

- Upward compatible from and coexistent with 802.11-1999.

- Supports both parameterized and prioritized QoS
  - Prioritized QoS provides relative differentiation between priorities.
  - Parameterized QoS provides managed delivery using traffic specification.
  - But as viewed from above the MAC SAP, there is only one service.

- Provided QoS under both (e)DCF and (e)PCF
  - Parameterized QoS only available under ePCF.
  - Improved efficiency through new and streamlined mechanisms.

- BSS overlap mitigation

- Structural elements to extend BSS coverage and connectivity
  - Bridge Portal (BP): Infrastructure access at non-AP location
  - Alternate AP/PC: To preserve BSS and QoS in case of failure.
1394 PAL (Protocol Adaptation Layer)

- Develop an implementation guidelines specification for a 1394 PAL that creates methods to:
  - mimic IEEE 1394 infrastructure (transactions, isochronous, stream data, configuration ROM and CSR architecture) using the facilities of IEEE802.11a and
  - implement IEEE P1394.1 bridge behaviors in the same domain.

- The methods are to be compatible with the simultaneous use of IEEE 802.11a by other protocols, e.g., Internet protocol.

Wireless 1394 PAL Bridge Model
New Home with Wireless Networking

Conclusions

- IEEE802.11, 15, 16 are hottest issues worldwide.
- IEEE802.11 WLAN achieved the greatest success.
- Networking technologies are addressed.
- Definitions of QoS are addressed.
- IEEE802.15 is coming up with security suites for the authentication process.
- Some technologies for Wireless LAN next generation will be playing an important role.
- Wireless 1394 with WLAN or WPAN backbone may be the solution for the future Home Networking.