

멀티미디어기기를 위한 GUI와 S/W 개발

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저작권에 대한 본 사항이 명시되는 한 상업적 이용을 포함한 어떠한 정보 매체에 의한 본문의 전재나 발췌도 사전 승인 없이 무상으로 허용됩니다. 그러나 본문에 대한 수정 및 침삭은 허용되지 않습니다.

Ver 1.3 - 2007.12.7

- Section – 1
 - 멀티미디어 기기 산업 동향과 사례 소개
 - Chip회사 동향
 - S/W시장 동향
 - Embedded 개발 tool소개
- Section – 2
 - S/W in new DTV
 - WinCE vs. Linux
 - Video Codec
 - Embedded UI
 - C/C++ library
- Section – 3
 - How to port library or applications
 - autoconf / automake
 - uClinux
- Section – 4
 - 기술표준
 - 최종 제품 만들기...

Section 1

숲을 둘러보고 나무를 관찰하기...

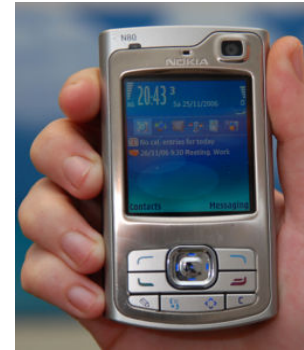
- Multimedia 정의
- Multimedia기기 분류
- 멀티미디어 기기 산업 동향과 사례 소개
- Chip회사 동향
- S/W시장 동향
- Embedded 개발 tool소개
 - Binutils
 - Compiler
 - library
 - 소스분석기
 - Source level debugger

(Lat. Multum + Medium) is media that uses multiple forms of information content and information processing (e.g. text, audio, graphics, animation, video, interactivity) to inform or entertain the (user) audience. *Multimedia* also refers to the use of (but not limited to) electronic media to store and experience multimedia content. Multimedia is similar to traditional mixed media in fine art, but with a broader scope. The term "rich media" is synonymous multimedia. Multimedia means that computer info can be represented through audio, graphics, image, video and animation in addition to traditional media(text and graphics)

ref) <http://en.wikipedia.org/wiki/Multimedia>

- Potable
 - Phone, PMP/DMB/Navigation, PSP, Internet tablet,...
- Set top box (이하, STB)
 - 위성, 지상파, Cable, IP-STB
- Home media
 - DVD, DivX player, DMA (Digital Media Adopter)
- 가전기기
 - TV, Home theater
- 게임기들
 - Wii, PS3, X-box360, GP2x....
- Etc
 - slingmedia , 전자액자

- Phone
 - 예) Nokia N80
- Internet tablet
 - Sony Mylo, Nokia 770
- PMP/DMB/Navigation
- UMPC (Ultra-Mobile PC)
- Audio device : mp3, MD
- ...



- Xbox 360
- PS3 / PS2
- Wii
- GP2x
- ...



- 위성 STB
- 지상파 STB
- Cable STB
- IP-Set top box
- Hybrid Set top box



❖ PVR function

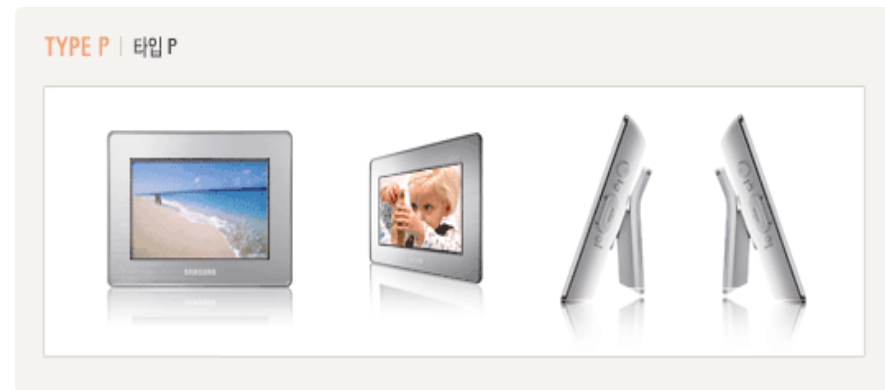
셋탑박스



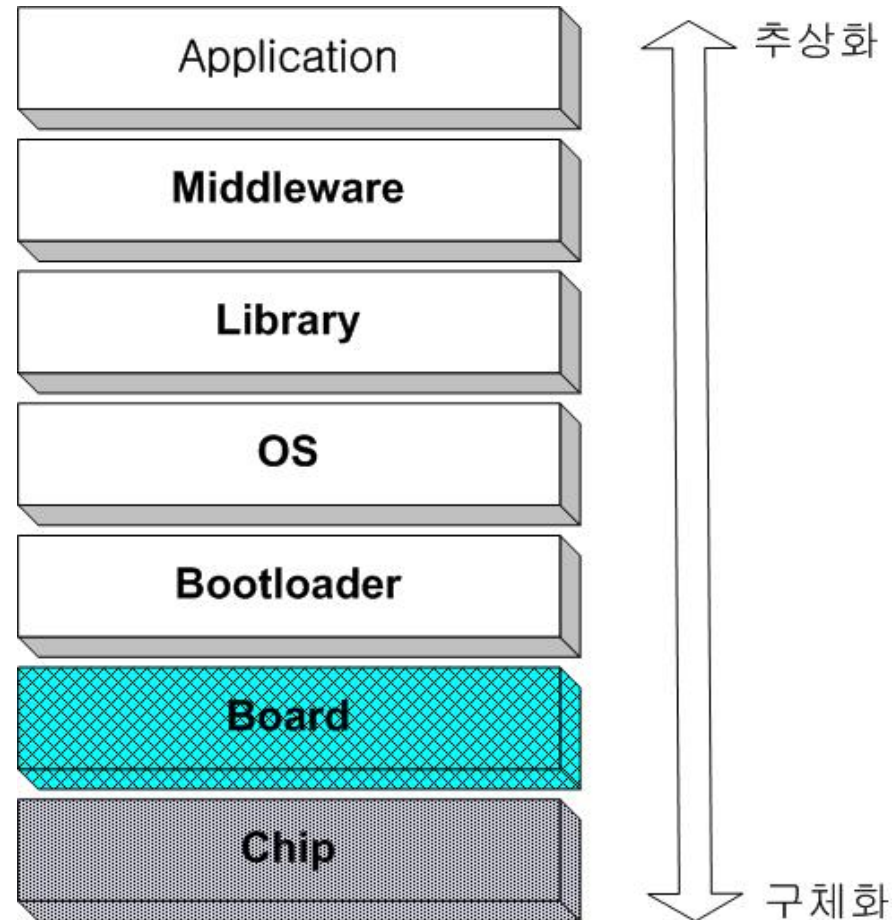
- DVD
- DivX player
- DMA (Digital Media Adopter)
 - Or Media Extender
- Hybrid player



- Placeshifting technology
 - SlingBox, Location free, Take out
- 전자액자
 - SKT러뷰 서비스



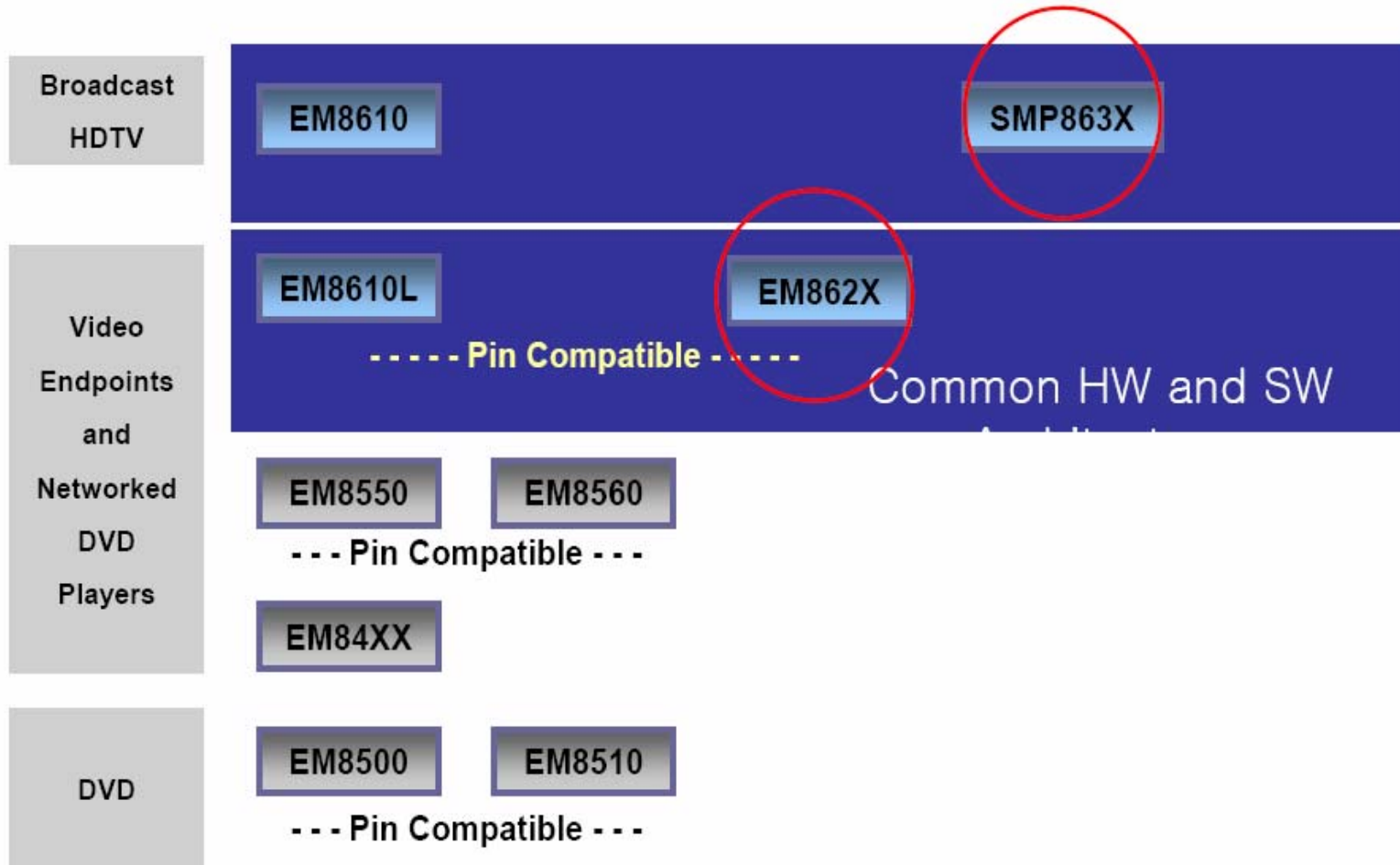
- H/W
 - Chip
 - case design
 - Board
 - 생산
 - ...
- S/W
 - Firmware
 - O/S
 - M/W
 - Application
 - Server
 - ...



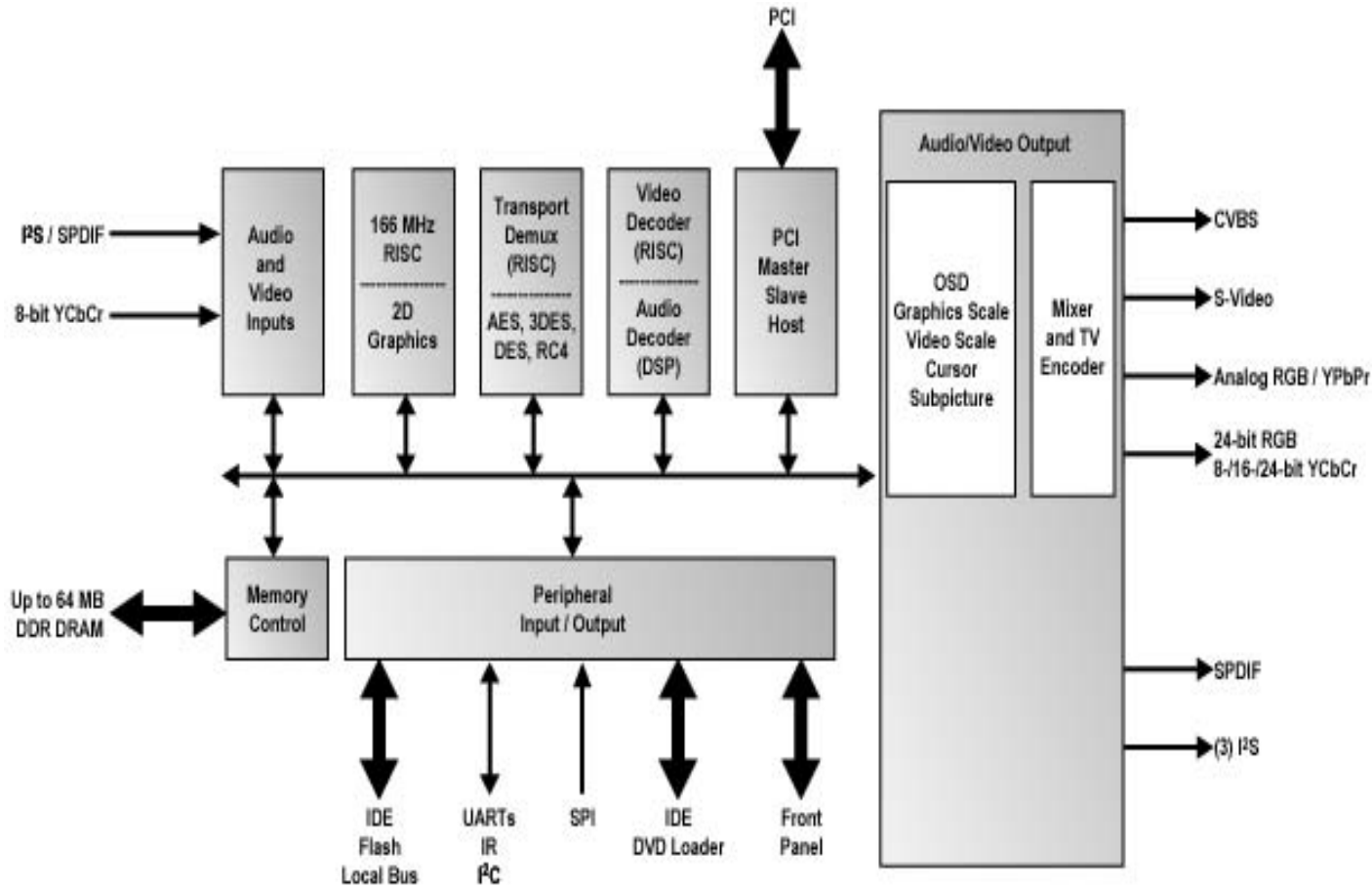
- H/W decoder 내장
 - SigmaDesigns
 - RMI (AMD)
 - 마이크로너스
 - NXP (Philips)
 - Intel
 - BroadCom
 - ST
- DSP / dual CPU
 - TI
 - ADI
 - FreeScale : i.MX
 - Magic-Eye
 - C&S
 - Corelogic

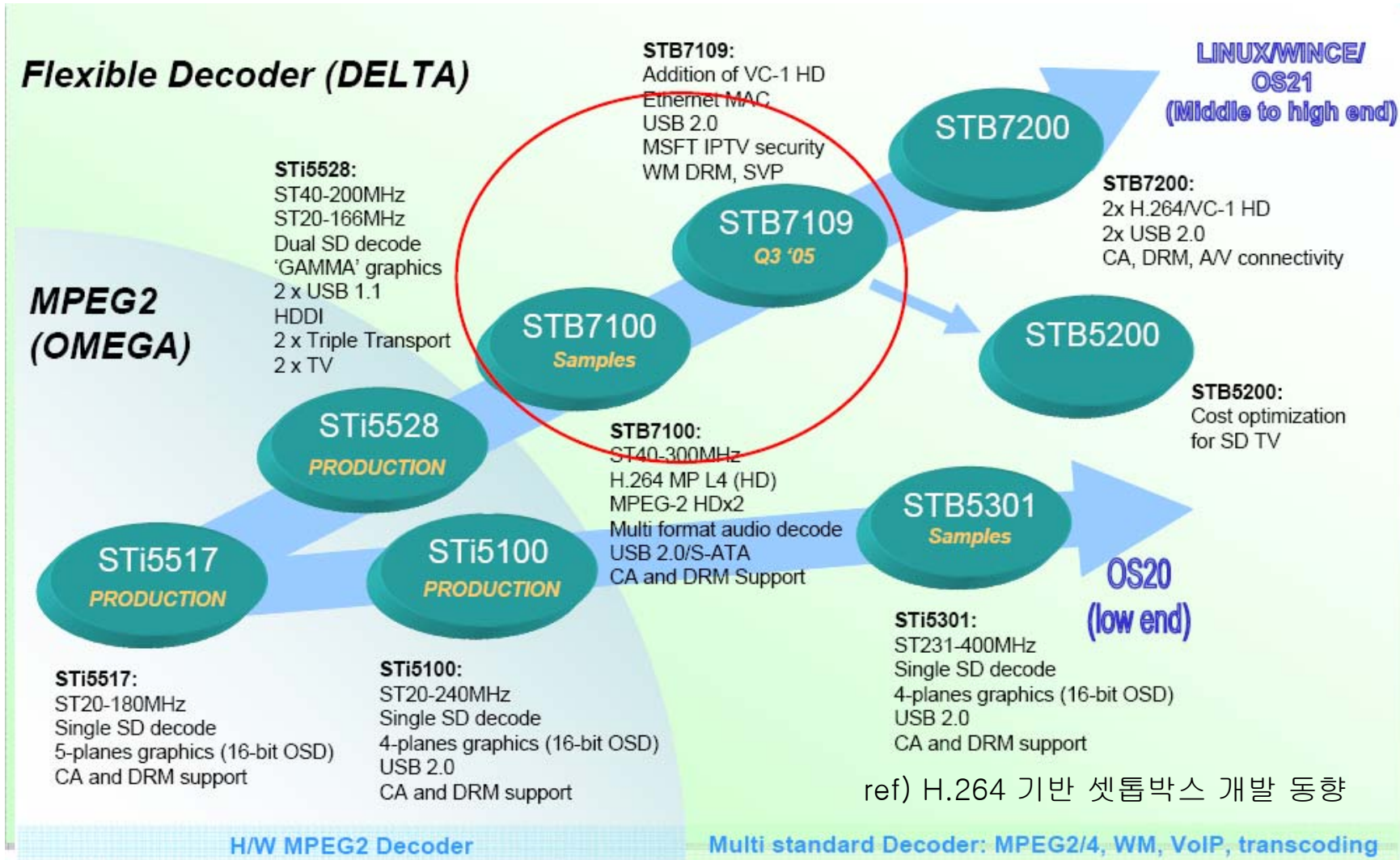


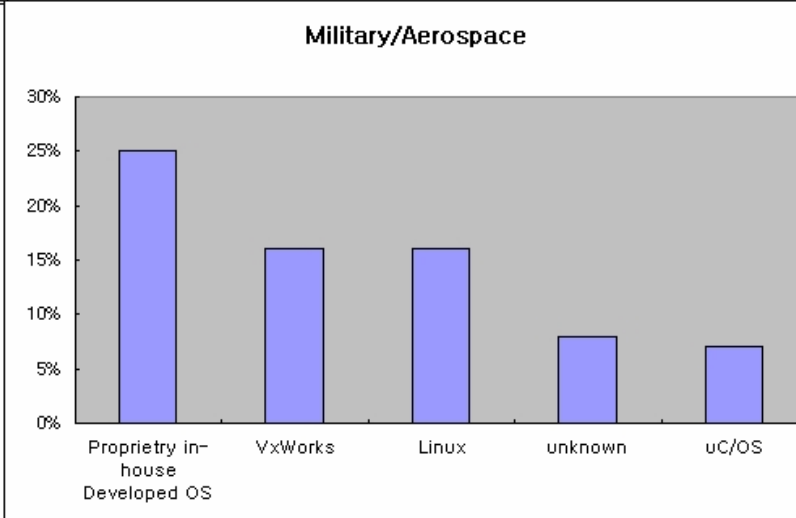
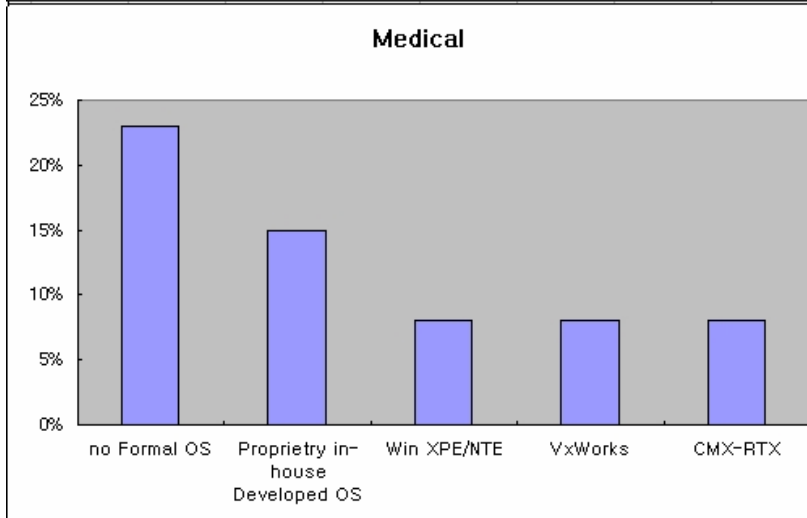
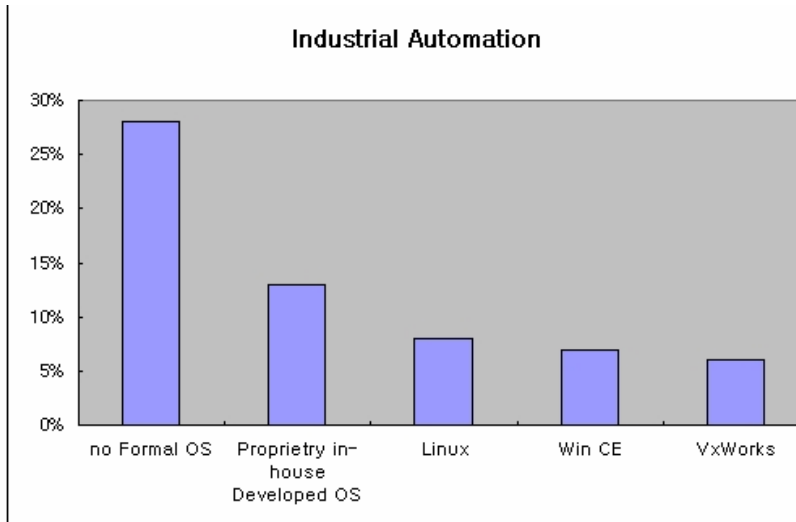
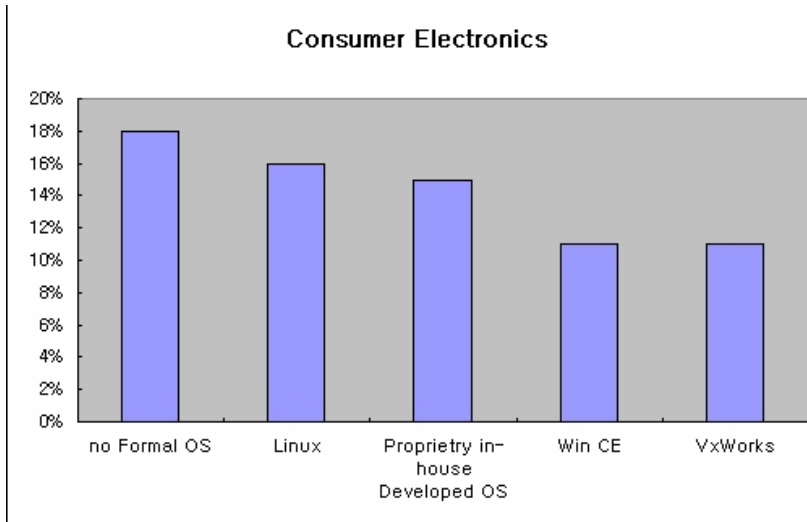
- Sigma Designs : EM8622L, SMP863X (SoC)
- BroadCom : BCM7411, BCM740X (SoC)
- Bonexant : CX2418X
- ST Micro : ST710X (SoC)
- Texas Instruments : TMS320DM642, TMS320DM644X (SoC)
- Vweb : VW40XX
- Wischips : DECYIPHER 8100 (SoC)



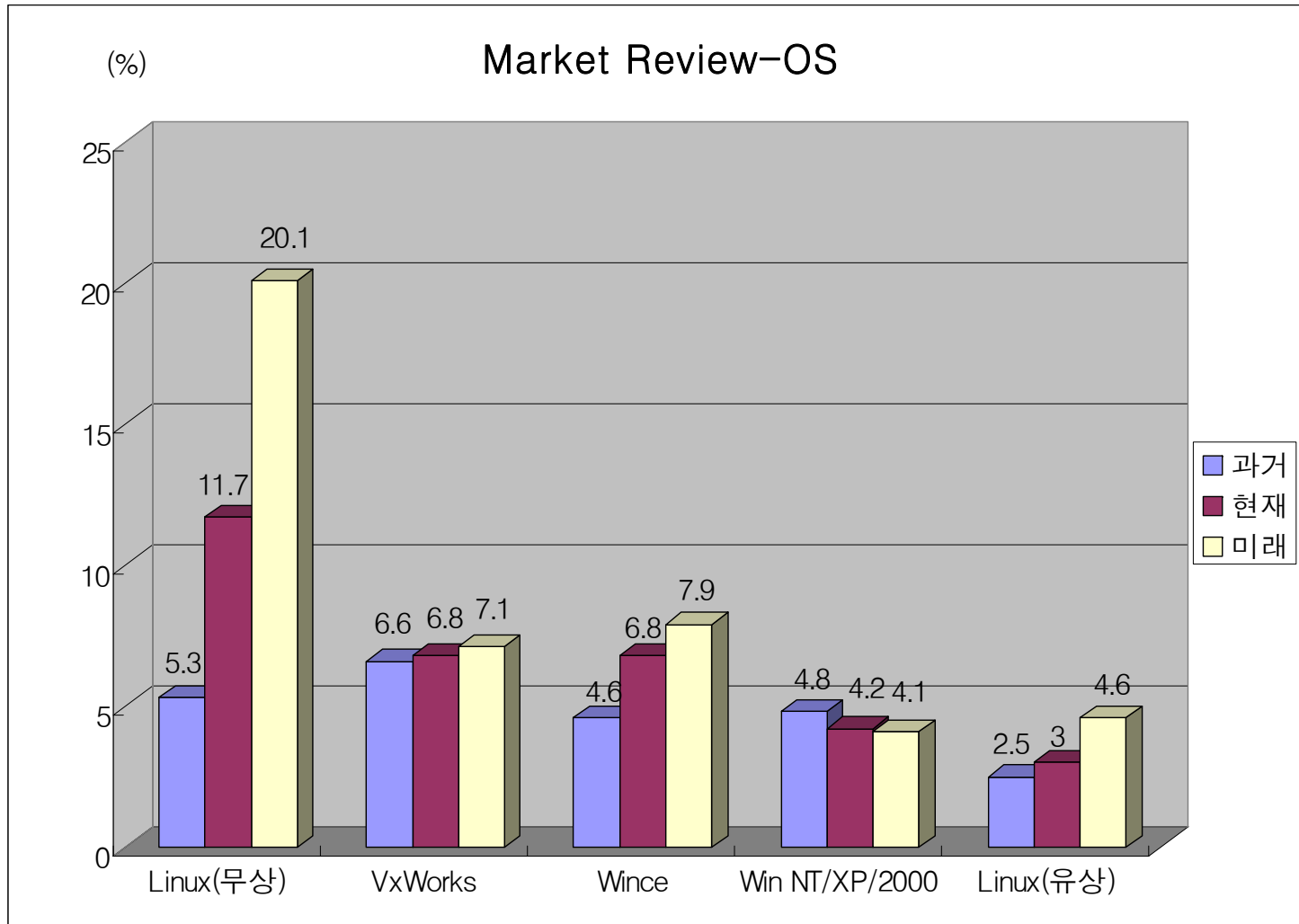
ref) H.264 기반 셋톱박스 개발 동향

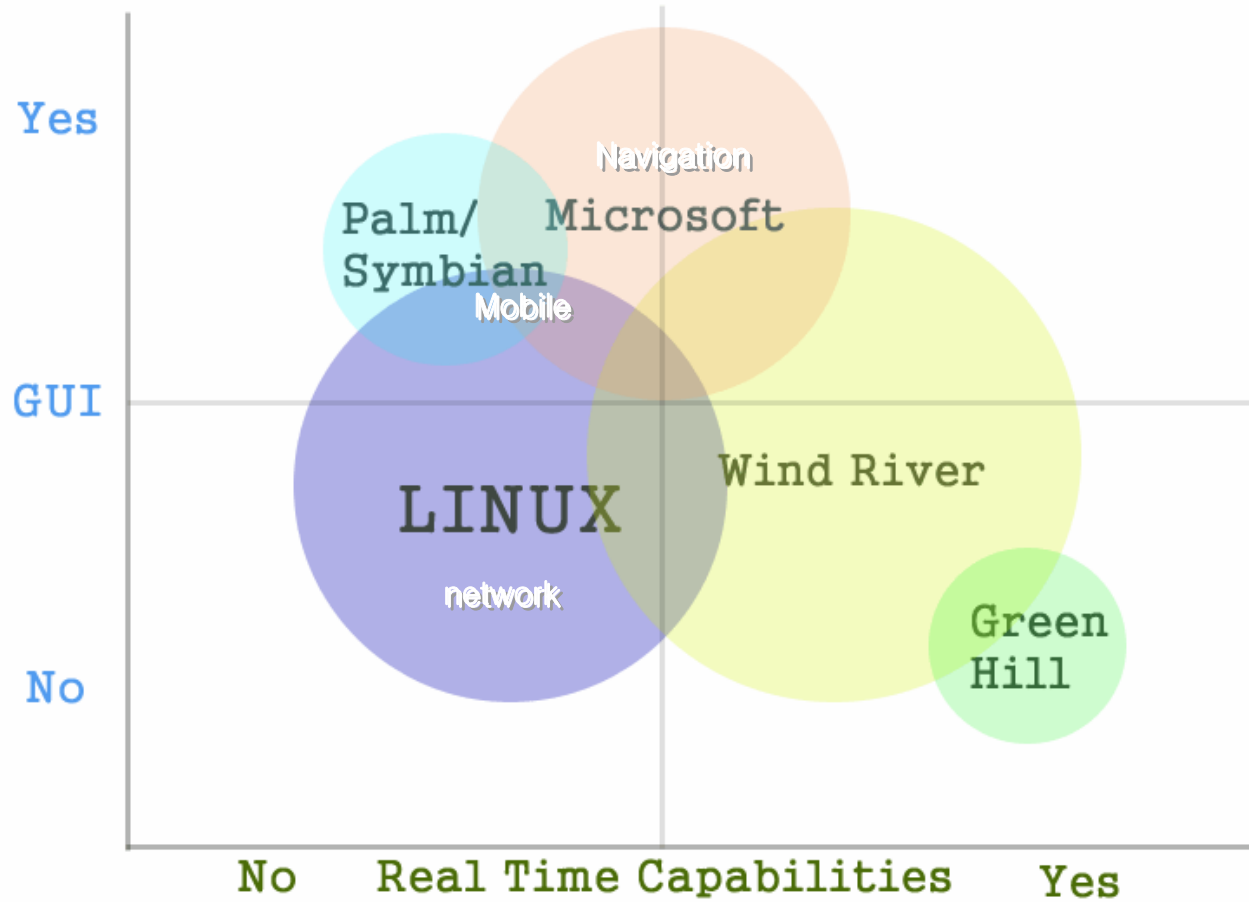






Ref) VDC, 2006





- 국내 navigation은 대부분 WinCE를 사용함 – 대부분 map회사가 WinCE만 지원
- TomTom navigation
미국 navigator시장을 가장 많이 선점한 TomTom회사의 대부분의 navigation은 Linux기반으로 되어 있음
ref) <http://www.tomtom.com/>



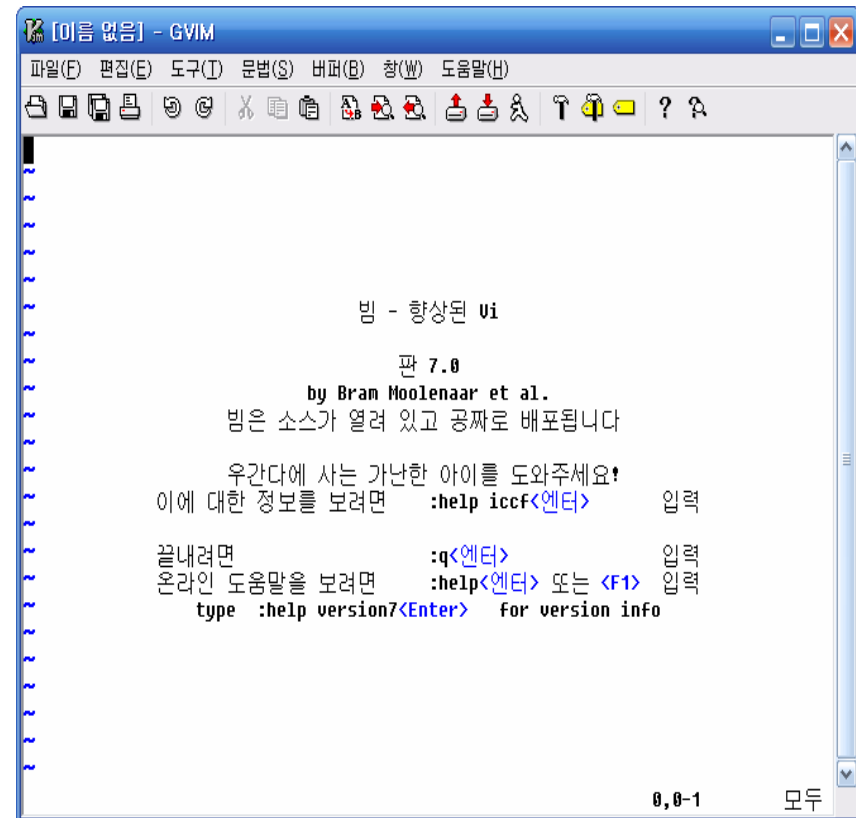
- 중저가 network 장비는 대부분 Linux기반
예) Linksys 대부분 AP
- 최근 embedded modem들은 eCos기반으로 만들어짐 <= 칩 회사들이 eCos 기반 SDK제공
- Network 제품과 modem쪽에서는 WinCE적용 성공 사례가 없음

- Binutils are a collection of binary tools.
 - `ld` – the GNU linker.
 - `as` – the GNU assembler.
 - `ar` – A utility for creating, modifying and extracting from archives.
 - `nm` – Lists symbols from object files.
 - `objcopy` – Copies and translates object files.
 - `objdump` – Displays information from object files.
 - `ranlib` – Generates an index to the contents of an archive.
 - `size` – Lists the section sizes of an object or archive file.
 - `strings` – Lists printable strings from files.
 - `strip` – Discards symbols.

 - `readelf` – Displays information from any ELF format object file.
 - `gprof` – Displays profiling information.
 - `addr2line` – Converts addresses into filenames and line numbers.
 - `c++filt` – Filter to demangle encoded C++ symbols.
 - `windres` – A compiler for Windows resource files.

- gcc : The GNU Compiler Collection
 - Front ends for C, C++, Objective-C, [Fortran](#), [Java](#), and Ada, as well as libraries for these languages C, C++, Objective-C, [Fortran](#), [Java](#), and Ada, as well as libraries for these languages
- Library
 - c/c++ library : glibc, uClibc, newlibc
 - Picture : libpng, libjpeg, ...

- Open source
 - vi : simple vi, vim, gvim
 - Emacs
 - ...
- Proprietary editor
 - visual slick editor
 - UltraEditor
- Freeware
 - editplus
 -



The screenshot shows a window titled "[이름 없음] - GVIM" with a menu bar (파일(F), 편집(E), 도구(T), 문법(S), 버퍼(B), 창(W), 도움말(H)) and a toolbar. The main text area displays the following Korean text:

```
vim - 향상된 vi
판 7.0
by Bram Moolenaar et al.
vim은 소스가 열려 있고 공짜로 배포됩니다

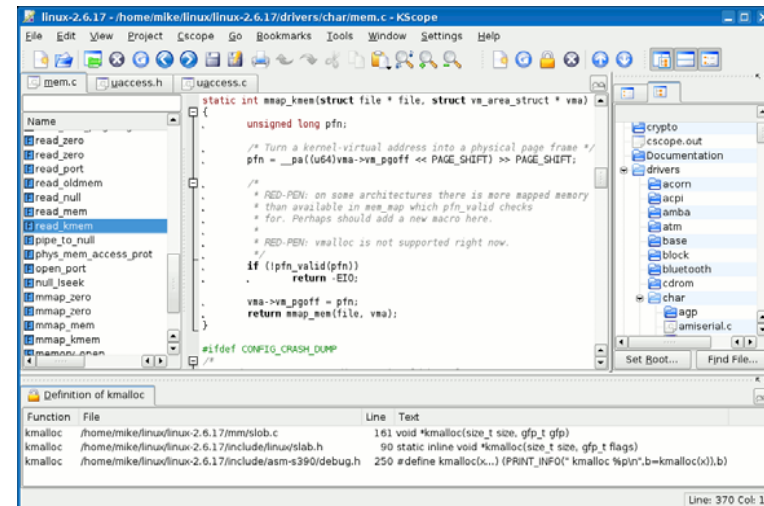
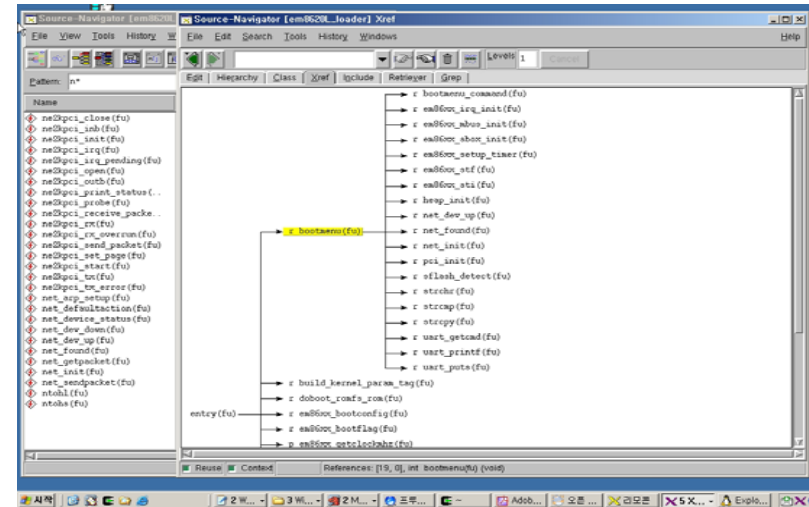
우간다에 사는 가난한 아이를 도와주세요!
이에 대한 정보를 보려면  :help iccf<엔터>   입력

끝내려면                :q<엔터>           입력
온라인 도움말을 보려면  :help<엔터> 또는 <F1>   입력
type :help version7<Enter> for version info
```

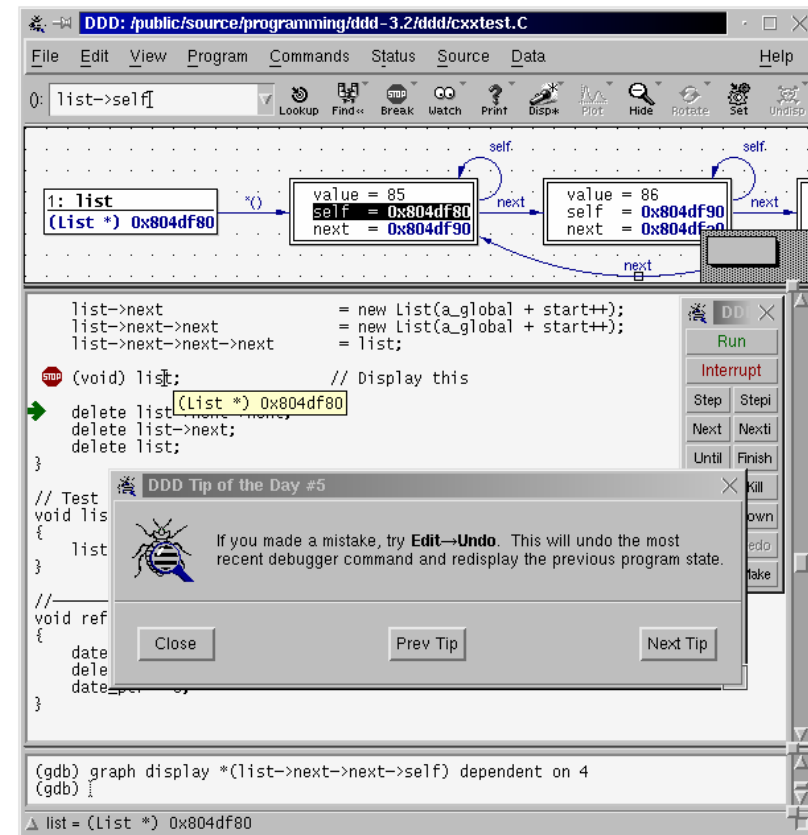
At the bottom right, the status bar shows "0,0-1" and "모두".

Editor선호 문제는 종교문제와 같다.

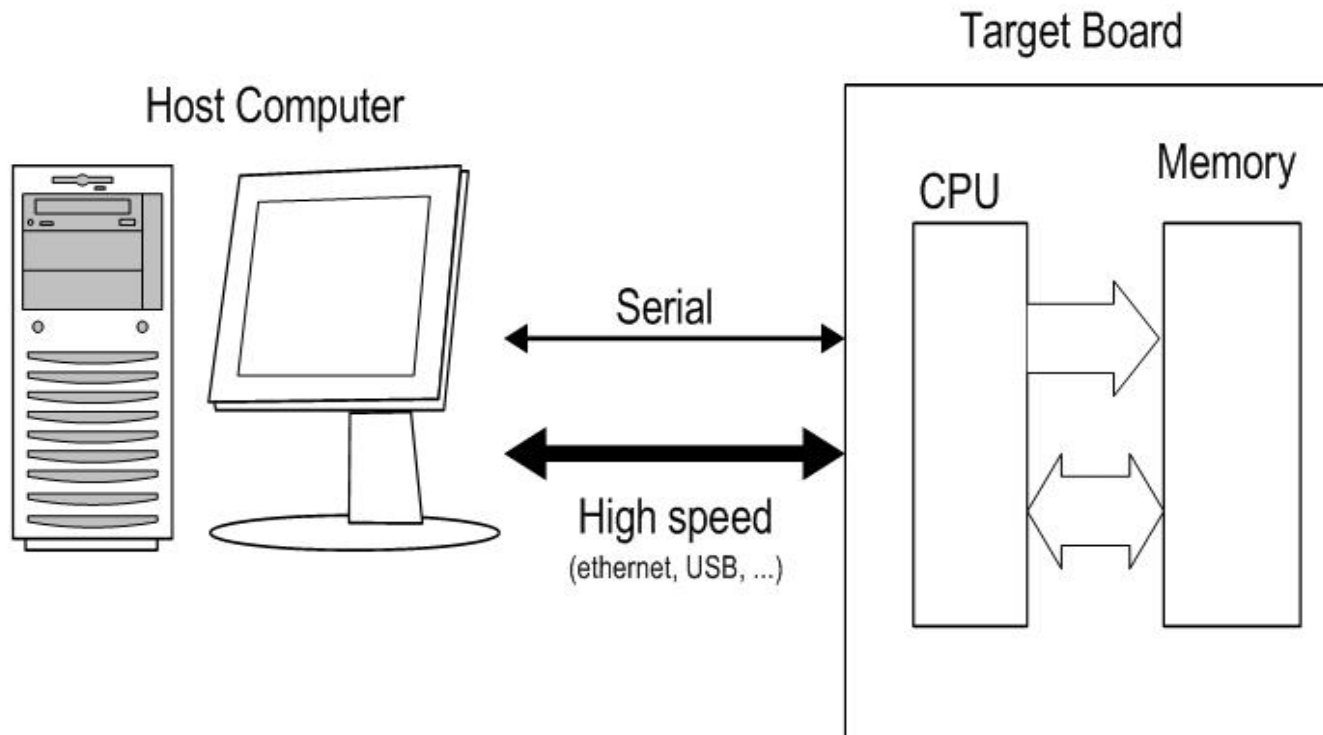
- Text
 - ctags, cscope
- UI
 - snavigator
 - cscope + UI
 - cbrowser
 - kscope



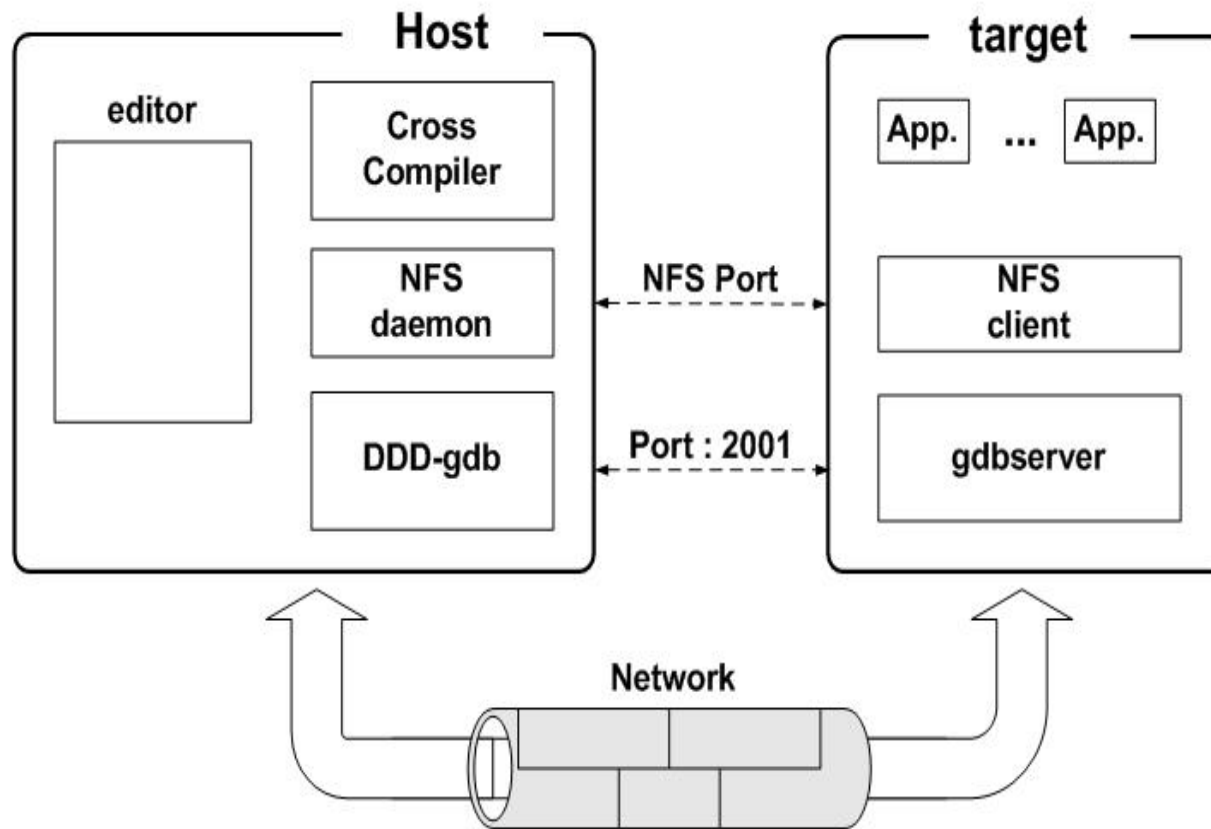
- gdb
- UI
 - DDD (Data Display Debugger)
 - : gdb의 backend로 동작하는 최고의 도구
 - insight

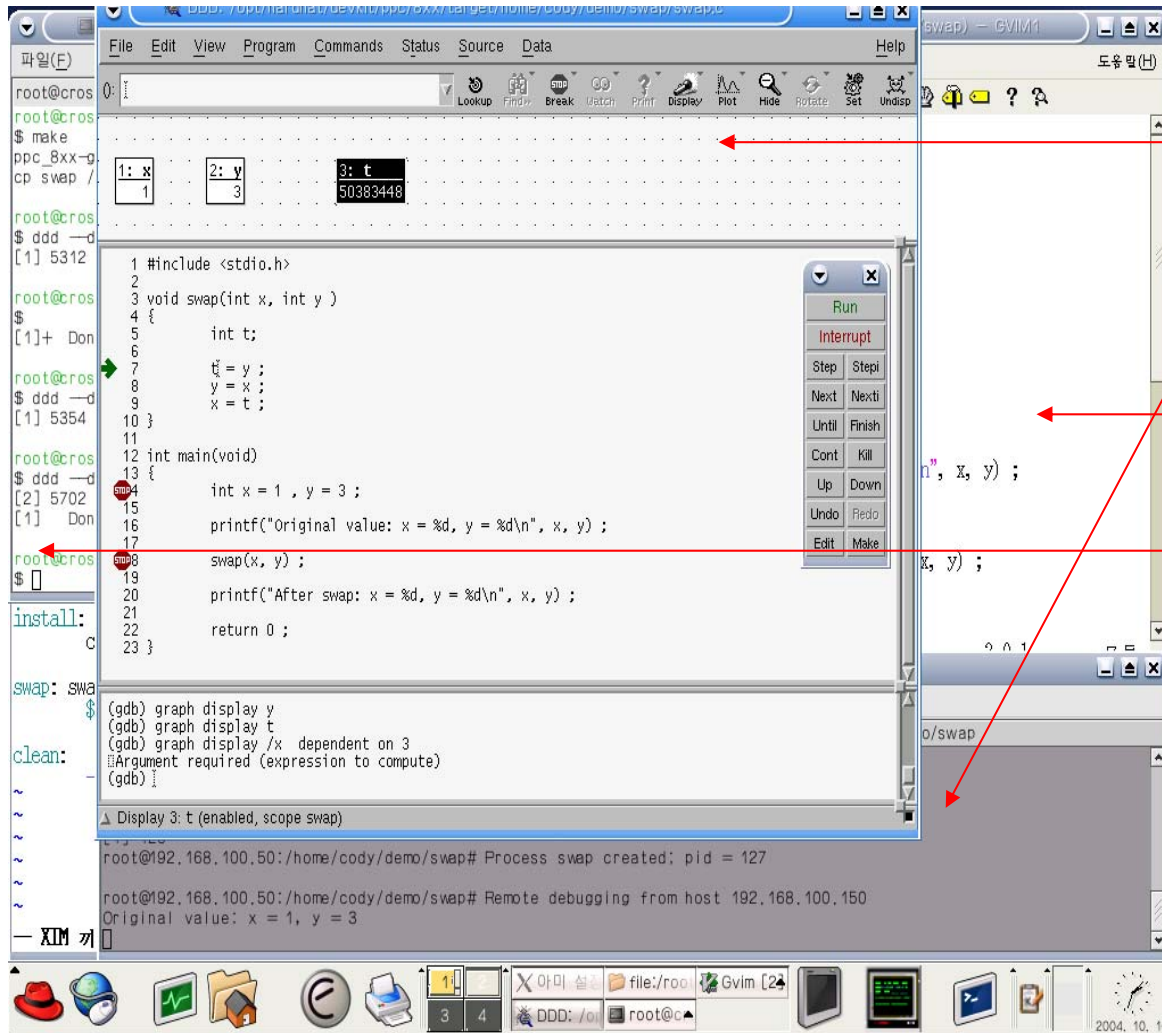


- Host와 target에 대한 이해필요
 - Host : 개발 환경을 사용하는 computer
 - Target : 실제 프로그램을 운용하는 장치



- 리눅스를 이용한 remote debugging 환경





* DDD(Data Display Debugger)

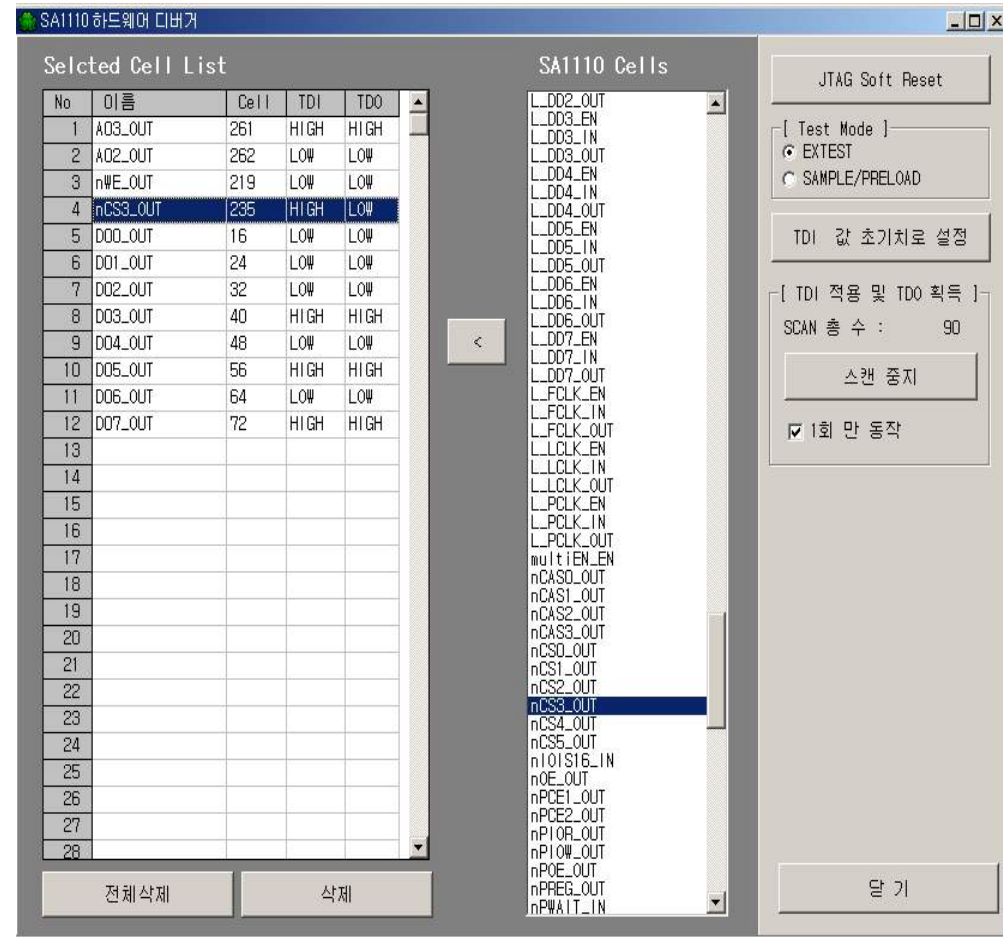
* 회색 창 : target serial console창

* 오른쪽 창 : target의 NFS에 있는 소스파일을 편집하는 창

* 왼쪽 창 : cross-compiler와 Debugger를 구동하는 host 창

- H/W 계측기
 - Oscilloscope
 - Logic analyzer

- JTAG / BDM
 - Test nail connection
 - Data read/write
 - Write Flash memory

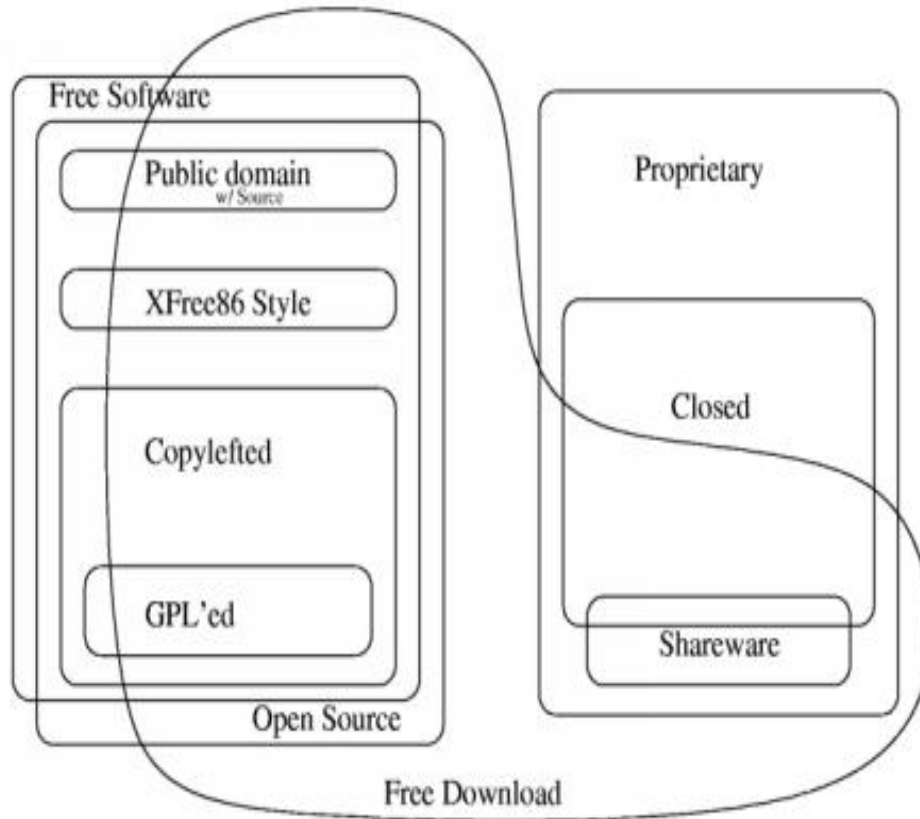


<JTAG tool> ref) www.falinux.com

- LCD module
- TV
- 보조 장치
 - Convertor
: TV output → VGA port
 - US TV 수신 card



- Categories of Free and



Module을 사용하는 이유

- Device driver 개발의 편리성
- Keep proprietary information according to LGPL (Lesser General Public License)

Ref) www.gnu.org

Section 2

시작이 반이다.

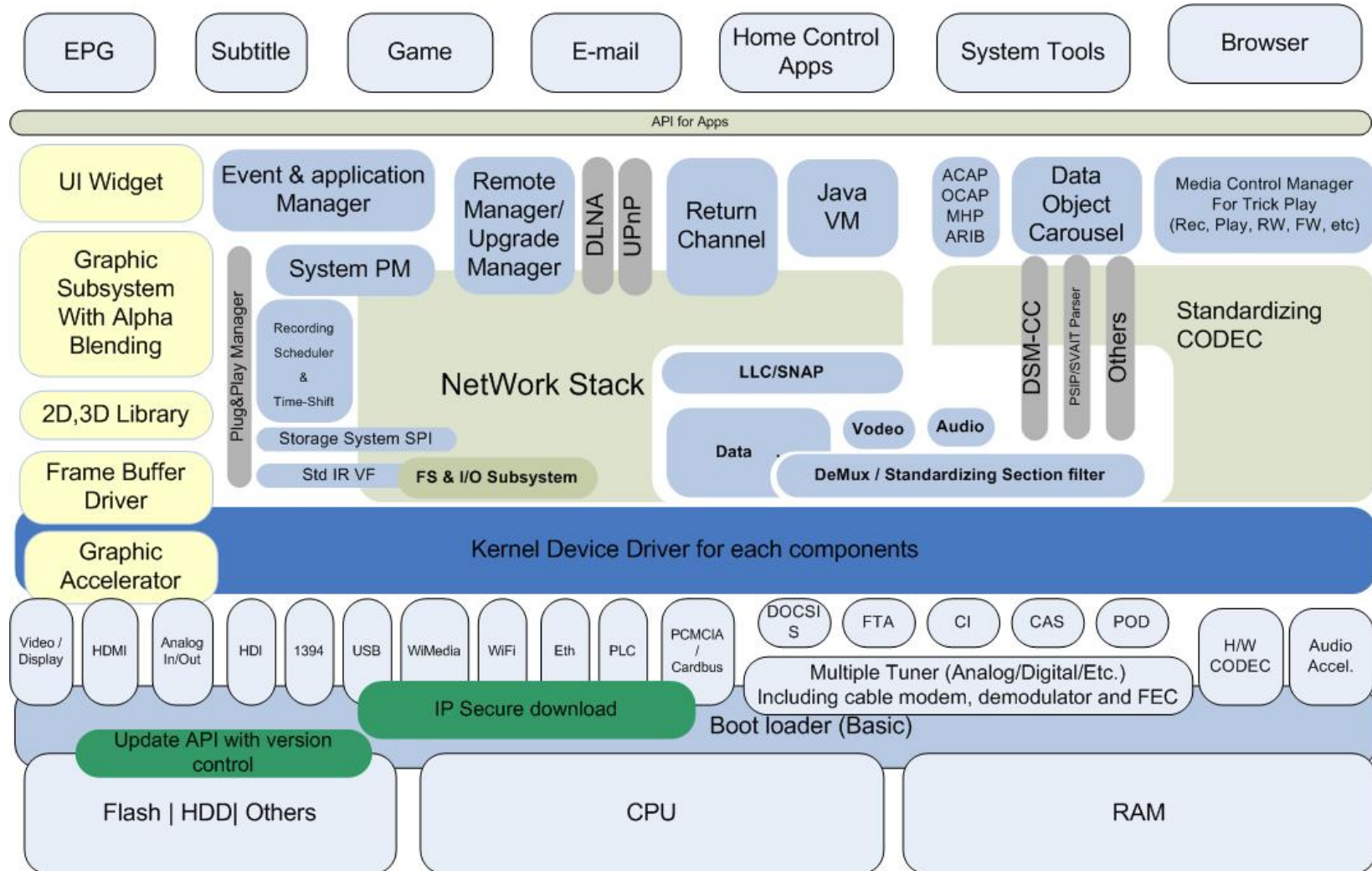


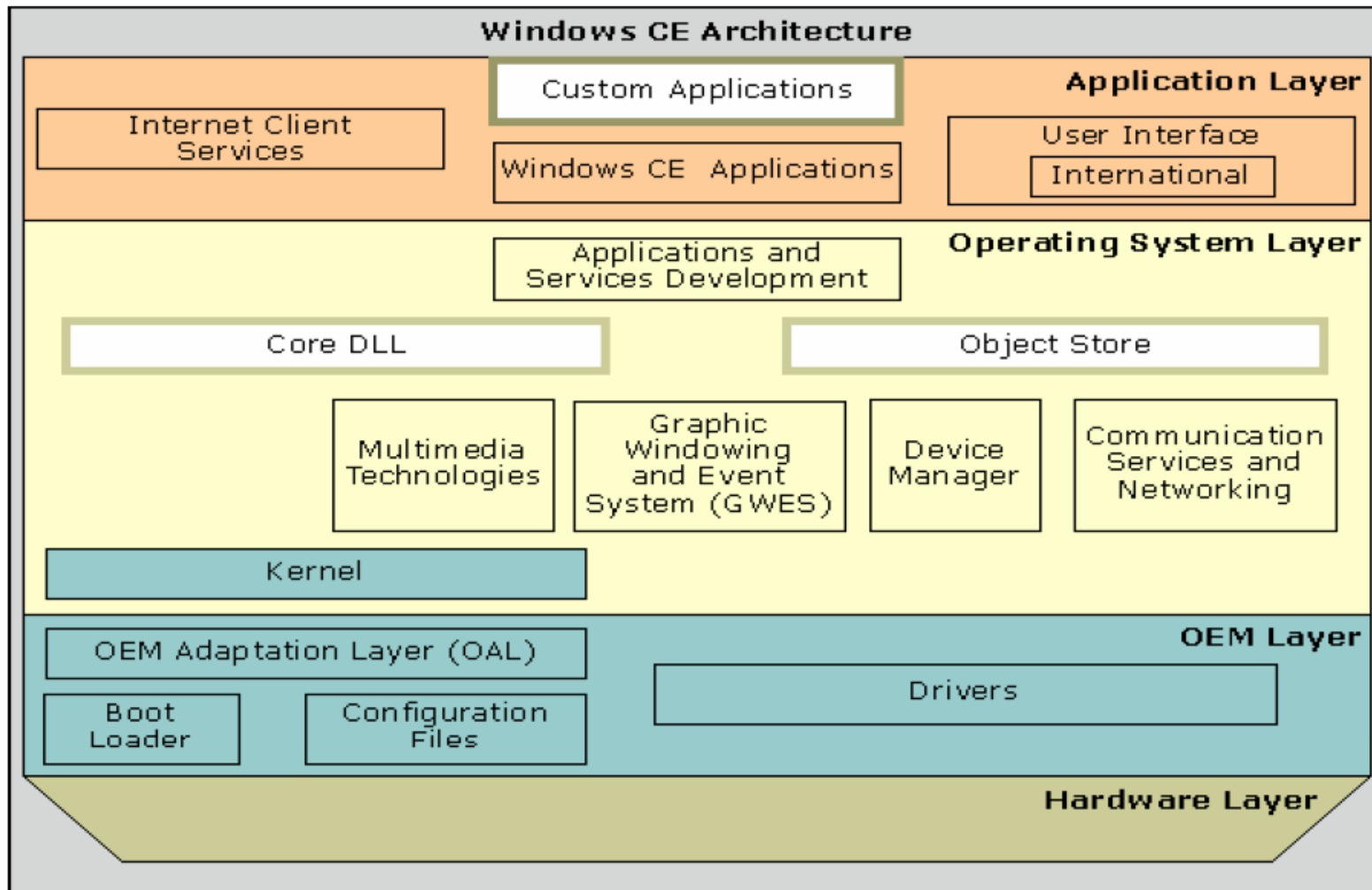
'Well begun is half done




시작이 좋으면 이미 반은 성사시킨 것이다.

- S/W in new DTV
- WinCE vs. Linux
 - Technical side
 - Marketing side
- Video Codec
 - MPEG1/2/4 and H.264
 - DivX / XviD
 - WMV9, asf and VC-1
- User interface 개발 방법론
- Embedded UI
 - Microwindows / Nano-X
 - GTK
 - QT/Embedded and Qtopia
 - MiniGUI
 - 비교 분석
- C/C++ library
 - glibc
 - uClibc





 Data Results	Windows CE .NET	Windows XP Embedded	All Windows Embedded	Embedded Linux
Total Time to Market, months	8.2	8.0	8.1	14.3
Software Engineers/Project, #	8.3	7.3	7.9	14.2
Development Man Months (mm)	68.1	58.4	64.0	203.1
Cost/mm of developer's time	\$7,500	\$7,500	\$7,500	\$7,500
Total Cost of Development	\$510,450	\$438,000	\$479,925	\$1,522,950
Comparative Savings (relative to Linux)	66.5%	71.2%	68.5%	0%

Comparative Total Cost of Development (with the same developer cost)

Ref) Total Cost of Development, 2003

Component	Included in embedded Linux? (1)	Average runtime license cost on Embedded Linux (2)	Included in Windows CE .NET? (3)	
			Core	Pro
Runtime Cost Volume Basis	10,000 units		10,000 units	
Real-Time Kernel	No	\$9.00	Yes	Yes
Web Browser	No	\$8.12	No	Yes
WMV9 Decoder	No	\$0.10	Yes	Yes
WMA9 Decoder	No	\$0.10	Yes	Yes
MP3 Decoder	No	\$0.75	Yes	Yes
MPEG-4 Decoder	No	\$0.25	Yes	Yes
WMV9 Encoder	No	\$0.20	Yes (5)	Yes (5)
WMA9 Encoder	No	\$0.20	Yes (5)	Yes (5)
Media Player	No	\$2.00	No	Yes
Digital Rights Management	No	\$10.00	Yes (6)	Yes
Residential Gateway App Stack	No	\$3.00	Yes	Yes
Terminal/Thin Client	No	\$14.00	No	Yes
Desktop Synchronization	No	\$10.00	No	Yes
Encryption Technology	No	\$20.00	Yes	Yes
Total Cost for all components (7)		\$77.72	\$2.60	\$9.00

Notes:

- 로열티 정책 비교
 - WinCE는 누적(Cumulative) 로열티 정책이 아님, 즉 주문할 때 생산 대수에 따라 로열티 추가함
 - 대부분 상용 sw들은 누적 로열티를 사용함, 즉 계속 생산되면서 로열티가 점점 줄어드는 방식 사용함
- 상용 s/w 정책
 - 상용 리눅스도 초기 도입비만 있고 로열티 추가하지 않는 제품도 있음
 - Chip회사에서 Linux SDK제공하는 경우도 많음
 - 상용 browser 로열티는 대략 \$1 ~ 5 사이에 추가됨 그리고 초기도 입비만 있는 제품도 있음
- Codec
 - MS가 mpeg1/2/4, H.264, AC3, DivX, DTS, Dolby 등 모든 특허를 갖고 있지 않음 => winCE 사용해도 별도 로열티 발생할 수 있음
 - 대부분 제품에서 일부 codec만 지원해도 됨 예) DVB-S2 셋탑에서는 H.264만 지원하면 됨
- CPU 문제
 - WinCE는 Linux보다 높은 CPU 처리 속도가 필요함
 - 지원안되는 CPU도 많음 : mmu 없는 종류, PowerPC, ARC...

Component	Linux	WinCE
Kernel	칩 회사에서 제공 / 오픈 소스 이용 / 상용 Linux *상용 Linux도 도입비만 있고 로열티 없는 제품도 있음	Tool 가격 / core license는 작음
Web browser	<ul style="list-style-type: none"> ▪ FireFox(Mozillar), KHTML, ... ▪ Opera, Oregon, Access, Espia, Espial, InfraWare, GeoTel => 상용 browser도 약 \$5 ~ 1 로열티임 ▪ 대부분 누적 로열티 정책 사용 - 생산되는 대수가 축적되어서 계속 로열티가 떨어지는 구조임 	Browser가 들어있는 pro license는 고가임 약 \$150이상 주문 로열티 정책 : 한번에 생산되는 대수에 따라서 로열티 부가, 생산이 계속 많이 되어도 로열티가 별로 줄어들지 않음
CODEC	<ul style="list-style-type: none"> ▪ H/W decoder 이용 ▪ open codec : ogg, Xvid ▪ 3rd party software 이용 	WMV, ASF, WMA이외에 CODEC은 특허를 MS가 갖고 있지 않음 - 별도 로열티 발생할 수 있음 예) H.264, DTS
Media player	<ul style="list-style-type: none"> ▪ mplayer, vlc, ... ▪ H/W decoder과 chip SDK이용 	PDA에서는 windows media player를 사용하지만 그 외의 제품에서는 customized player를 사용
Digital right management	3rd party 이용 : NDA, SecureMedia, ...	MS DRM이외에는 3 rd party 이용해야 함
TCP/IP stack	Excellent	Not sure?
Security	Everyday has patched	Everyday tried to crack
L2 / L3 routing protocol	Excellent	No
Total royalty	\$0 - ?	\$2.x ~ 15 ~ over 20

- Linux + Mozilar browser 사용하여 100만대 이상 단일 모델 판매 됨 => 가격 경쟁력이 있음
- 주요 특징
 - 스웨덴 회사, 유럽 시장에 강함
 - <http://www.kreatel.com>
 - IP 셋톱박스 기본 기능 위주로 제품 개발
- IP-STB 1710/1720
 - MPEG-2 / H.264 / Windows Media 9 지원 셋톱박스
 - CPU
 - ATI Xillion 220
 - H.264 디코더
 - Texas Instruments사의 DM642 DSP
 - 운영체제 : Linux
 - DVT-T Tuner 내장 (IP-STB 1720)



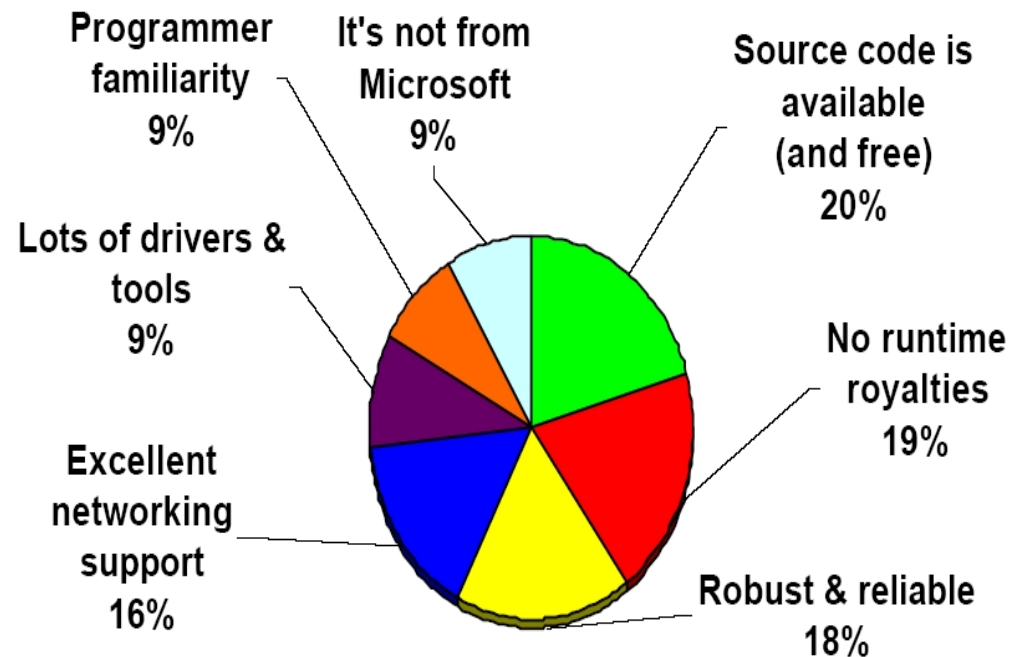
- Not proprietary
- Robust & reliable
- Excellent network support
- Very fast development speed
- Abundant software

- Many CPU support
- Good people
- For developing hacker
- Very fun
- Open source not black box
- according to GPL* and LGPL

* GPL : General Public License

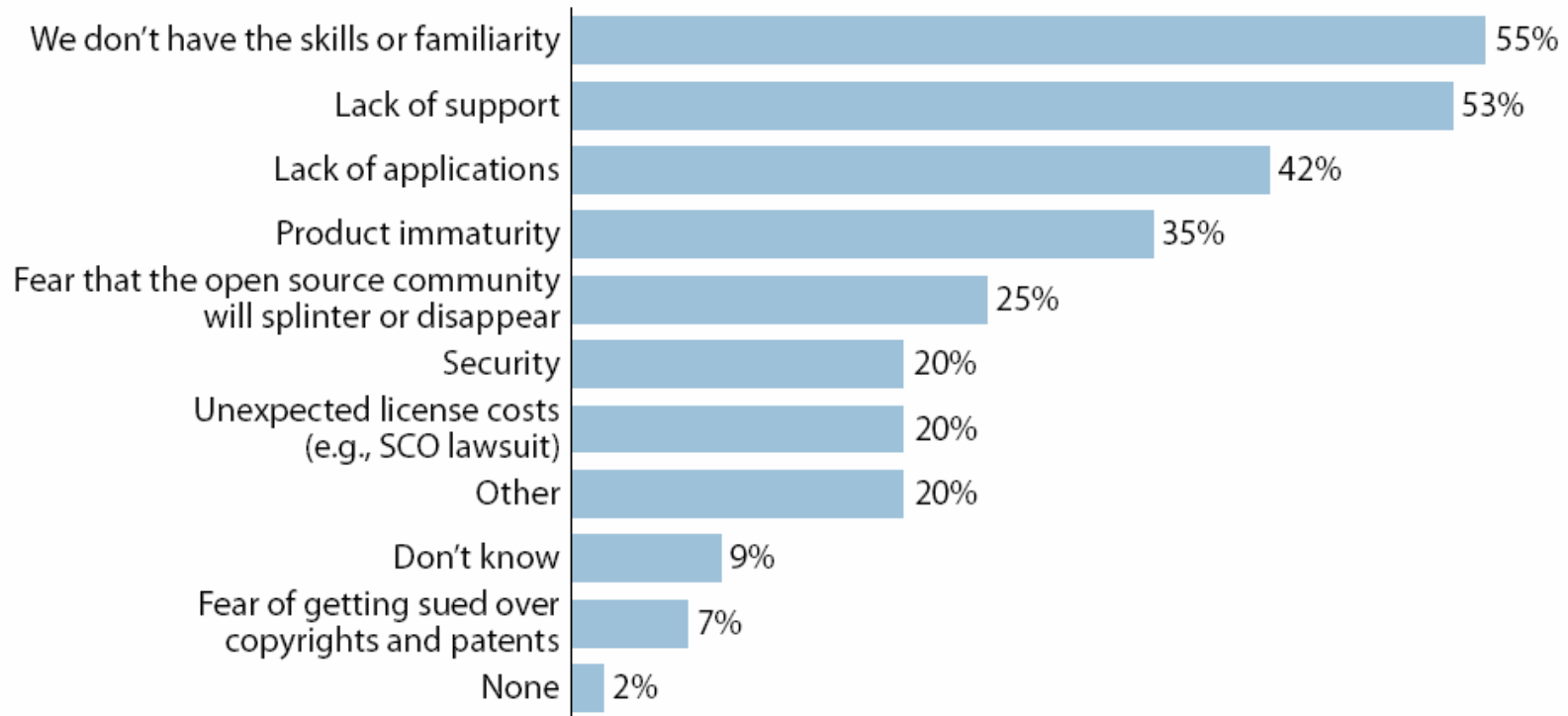
** LGPL : Lesser GPL

Why are you considering using Linux in an embedded Application?



Ref) linuxDevice.com

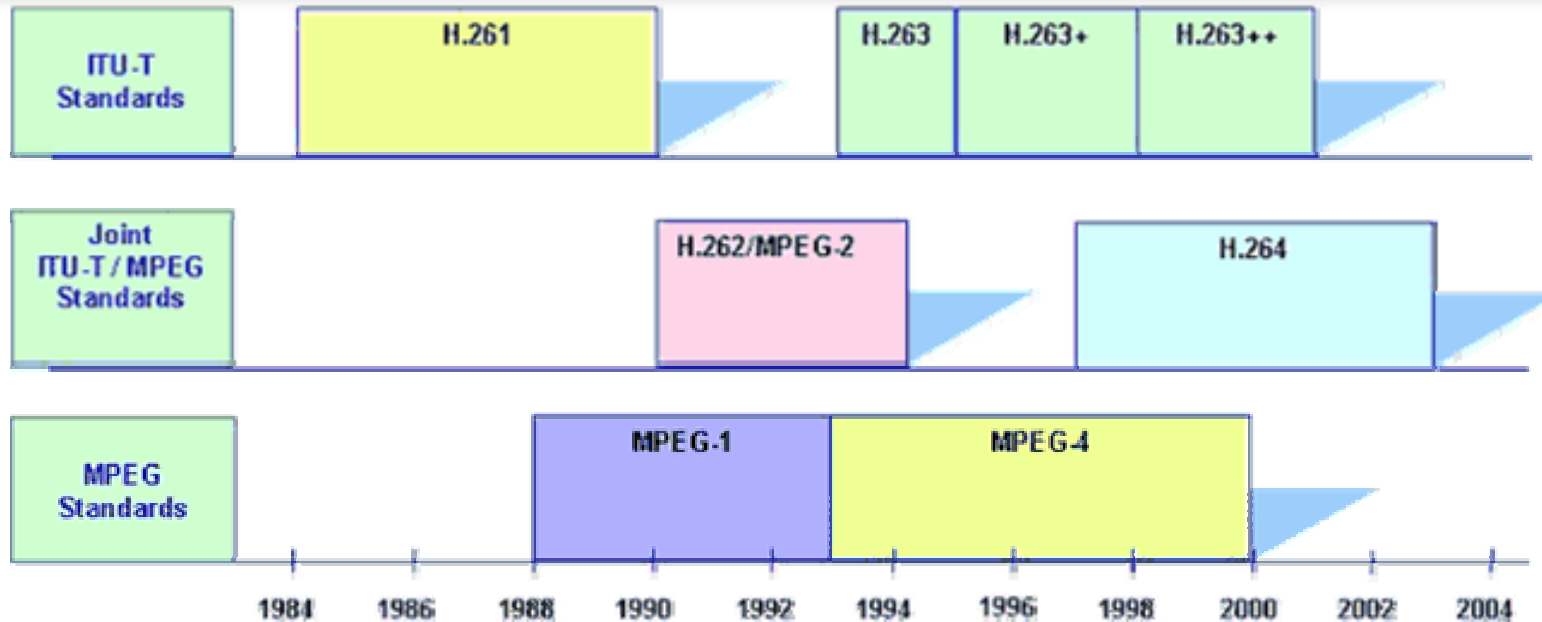
“If you are not using or planning to use Linux or open source, why not?”



Base: 55 North American firms that do not use or plan to use open source software
(multiple responses accepted)

Source: March 16, 2004, Trends “Open Source Moves Into The Mainstream”

Source: Forrester Research, Inc.



- MPEG-4 SP

차세대 휴대용 단말기와 협대역 인터넷에 사용

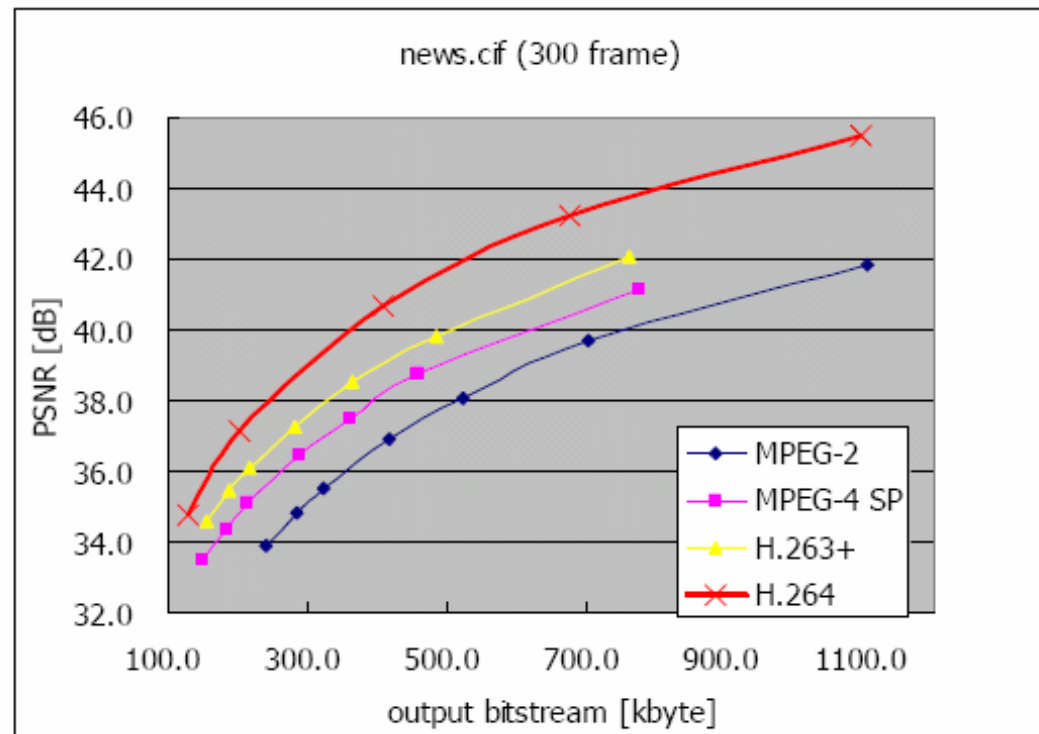
- MPEG-4 ASP

MPEG-4의 simple profile에 추가로 ¼ 화소단위 움직임 추정 (quarter pel resolution motion estimation)과 전역 움직임 추정 (global motion estimation)이 구현되어 있는 profile 1.5에서 2.0배정도 효율을 높였음.

- MPEG-4 Part 10(H.264)

MPEG2에 비해서 높은 압축률과 좋은 화질, 높은 에러 정정율을 가지며, 인터넷 방송이나 이동통신용으로 개발되었다. Profile이 너무 다양하다

- PSNR example
 - News, CIF, 30 Hz



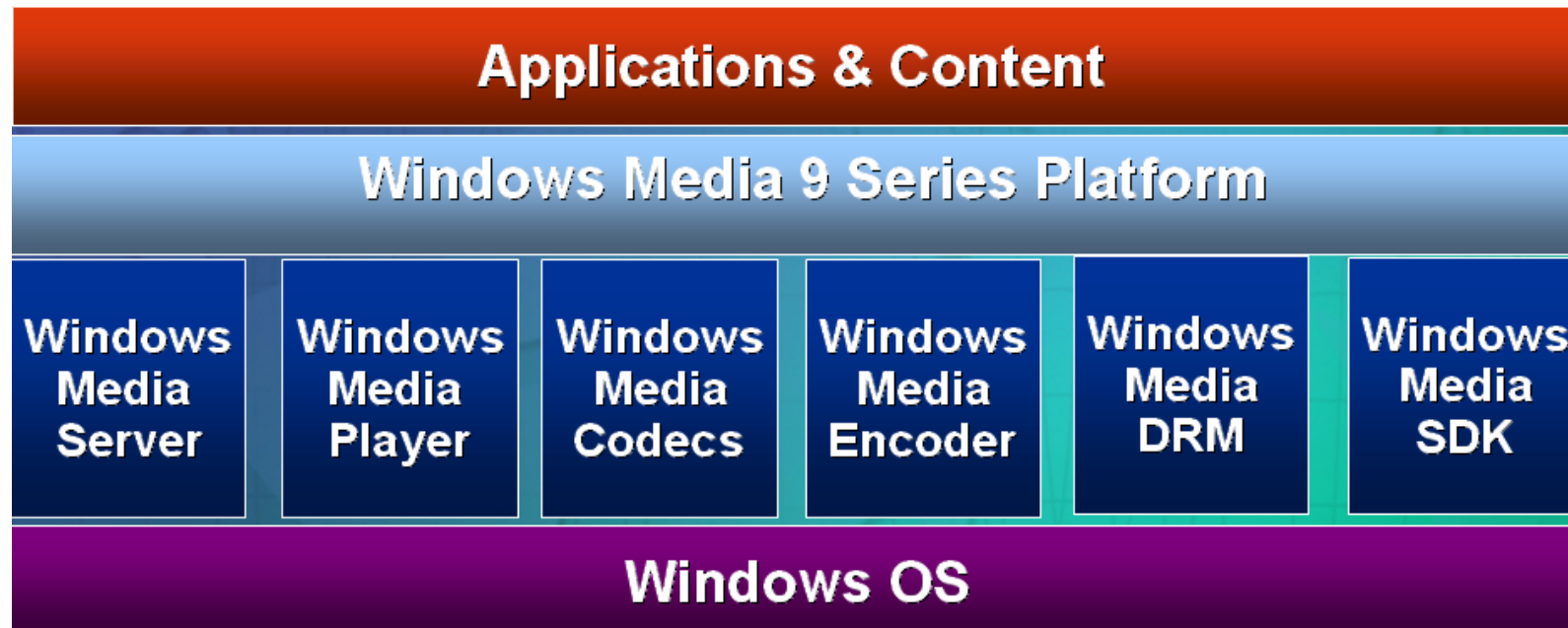
* PSNR : Peak Signal to Noise Ratio

- Divx3.11
 - 맥스모리스라는 닉네임을 가진 프로그래머가 마이크로소프트가 ASF 파일 형식을 위해서 만든 MPEG-4 코덱에 걸려 있는 제한을 바이너리를 조작, 변경 가능하게 하고 음성은 MP3로 대체한 코덱
- Divx4.0
 - DivX3.11 alpha와는 별도로 여러 가지 시험용 코덱들이 개발되었는데 그중에 Project Mayo 그룹에서 개발한 DivX 4.X(4.12까지 발표되었음)도 있다. DivX 4.X는 기본적으로는 DivX 3.X와 호환성을 가지고 있으나 실제 업그레이드 버전이 아니라 별도로 만들어진 코덱이기 때문에 많은 문제를 가지고 있다.
- Divx5.0
 - DivX의 개발자 중 한 명인 프로그래머 제로미 로타는 조던 그린홀과 공동으로 DivX 네트워크를 설립하고, DivX 5.0를 출시했다. DivX 네트워크는 많은 네티즌의 비판에도 불구하고 DivX 상용화에 박차를 가하고 있다. DivX 5.0은 기존의 DivX와 달리 상용화된 제품인 것이다.
- XviD
 - DivX의 상용화에 반발해 XviD라는 새로운 코덱이 개발됐다. DIVX에서 DivX의 이름을 따 왔듯이 XviD는 DivX를 거꾸로 쓴 이름이다.

- ASF
 - ASF는 ‘Advanced Streaming Format’의 약자로 마이크로소프트가 내놓은 스트리밍이 가능한 컨테이너 형식이다. 마이크로소프트는 어도비, 인텔, 리얼네트웍스, 바이보(Vivo)와 함께 AVI의 인터넷 확장판으로 볼 수 있는 ASF라는 새로운 멀티미디어 파일 표준을 공동 개발했다.

- VC-1(formerly VC-9)
 - 마이크로소프트사의 멀티미디어 표준으로서, 실시간 전송이 가능하고, VBR(Variable Bit Rates)을 지원함
 - 텔레비전을 위해서 비디오를 압축하려고 제안된 SMPTE 표준

- Windows Media Audio 9
 - Windows Media Audio 8보다 20% 향상된 음질
 - 새로운 가변 비트 전송률(VBR) 오디오 지원 기능으로 품질은 더욱 향상
 - 크기는 더욱 작아져 전보다 많은 음악을 저장

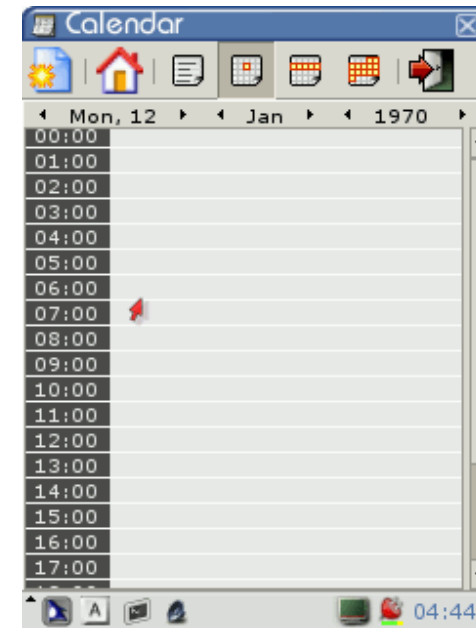
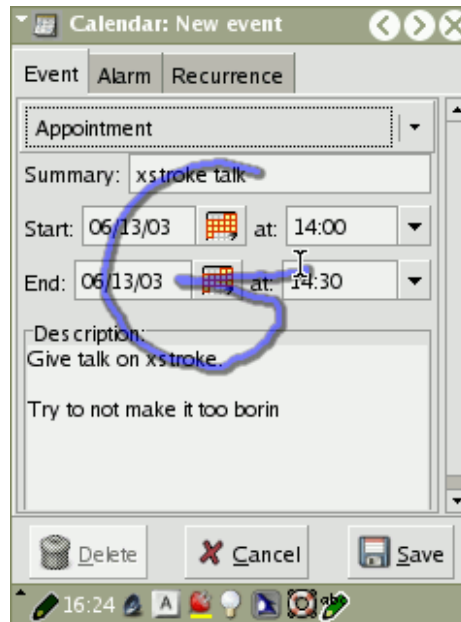


- Library부터 직접 제작
- 기존 library 기반으로 application만 작업 – QT, GTK+, MicroWindows, ThunerWin,...
- UI generation tool – Flash, Planetweb, ...
- Web browser – Opera, Oregon, ANT, OpenWave, InfraWare, GeoTel,...
- Java Virtual Machine – J2ME
- Platform – WIPI, Brew

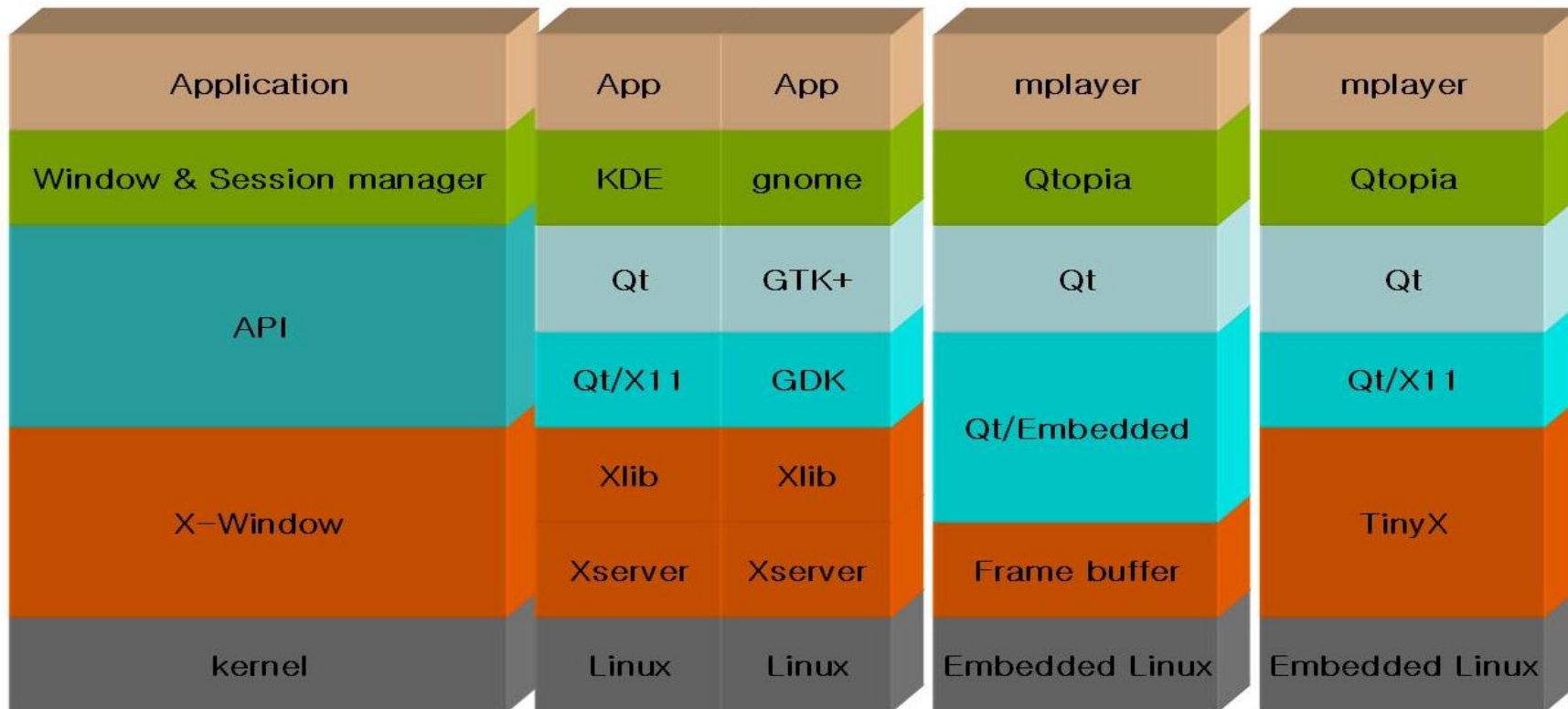
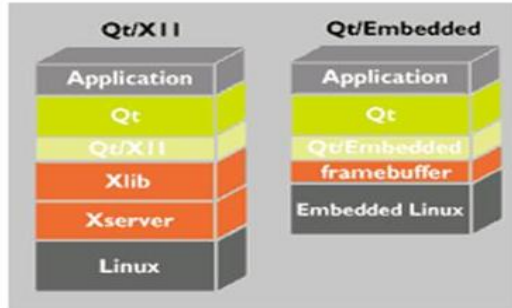
- License: Mozilla Public License. Allows proprietary applications.
- Very lightweight) portable graphics library, running on Linux kernel framebuffer, X / Windows, SVGAlib and a few other systems.
- 2 APIs (C language)
 - Win32 graphics device API: allows easy porting of Windows or WindowsCE programs.
 - Nano-X API: small X server with Xlib-like API
- API documentation, FAQs and tutorial on the project page.
- Limitation: lack of skin support.

- License: LGPL
- The exact same toolkit as on the desktop
- Size: a bit bigger than the others (approx 4–5 MB on glibc / arm)
- C native API. Bindings for many other languages (e.g. gtkmm for C++)
- Usually run with an X server (TinyX / kdrive in embedded systems). Also supports DirectFB (no X server).
- Based on Cairo for vector graphics since version 2.8.0. Issue for systems with no floating point unit, as a few parts of Cairo rely on floating point computation. Things are improving, this issue is not completely solved yet (Apr. 2007 status).

- GPE = GPE Palmtop Environment, based on the GTK+ toolkit
- Uses the framebuffer X server from <http://freedesktop.org/>. Doesn't look heavy. Easy to display applications on a remote (PC) screen.
- Comprehensive set of tools for PDAs: PIM, e-mail, web browser, multimedia, configuration tools, LinPhone...
- On screen handwriting recognition
- Existing GTK applications can be run with few or no changes



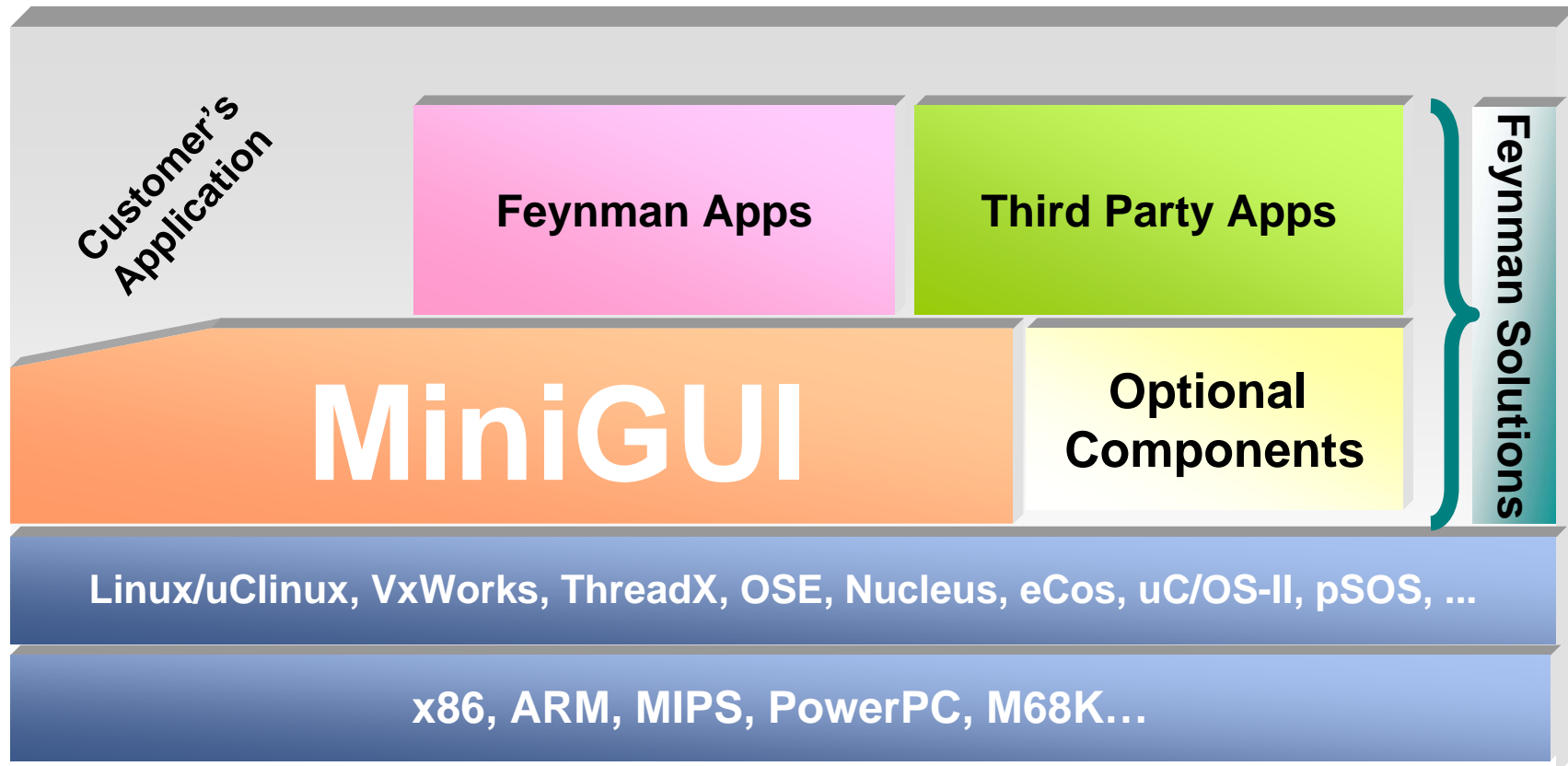
- Formerly Qt Embedded
- License: GPL
 - Need to get a commercial license to create proprietary software.
- Language: C++. Same API as Qt Desktop. Easy to port applications.
- Framebuffer based (instead of X server), with its own windowing system.
- Customizable look and feel
- Completely modular to reduce size and memory footprint. Size: from 1.1 to 3 MB (x86).
- Integrates with several Java VM. Same look and feel as native applications.
- Tools to test and develop on the desktop.



- <http://www.trolltech.com/products/qtopia/>
- License: GPL (same as Qt Embedded)
- Full set of Qtopia Core applications for PDAs (PDA Edition) or phones (Phone Edition)
- Featured applications: PIM, productivity, email, games, media player... Phone interface in the Phone Edition.
- Synchronization with Qtopia Desktop or MS Outlook.
- Community, developer resources (tutorials), forum and device list available on <http://qtopia.net/>



- In December 1998, Mr. Wei Yongming began to develop MiniGUI, and applied it in a computerized numerical control (CNC) system as GPL license
- Later, only commercial license for new version
- Compatibility with Win32 API
- Support various font type : TTF, BDF, QPF, TYPE1 and in-core type
- Small footprint
- High performance
- Support multiple character set: unicode, euc-kr, ISO8859-1
- Support for cross-platform, including Linux/uClinux and RTOS – UbiFOS, VxWorks , eCos, uC/OS-II, ...



GUI Features	MiniGUI	MicroWindows	GTK+	Qt/Embedded
API	Win32 Style	X, Win32 subset	Private	QT(C++)
API Completeness	Yes	Incomplete with Win32 Support	Yes	Yes
Typical Size of function base	700K	700K	1.2M (Not included the dependencies such as Pango, Cairo, ATK...)	1.5M
Portability	Excellent	Normal	Too many dependent libraries to be ported together	Normal
License	GPL/Commercial	MPL	LGPL	QPL/GPL/Commercial
Multi-Process Support	Yes	Only support under X Window	Only support under X Window	Yes

GUI Features	MiniGUI	MicroWindows	GTK+	Qt/Embedded
Robustness/ Reliability	Good	Very Poor	Good	Good
Multi- language support	With unique multi- character-set support, a better option for embedded systems	Fair	Fair	Low efficiency with the introduction of UNICODE
Configurab lity and Customiza bility	Good (Strong configurability with lots of compilation configuration options)	Fair	Poor	Poor
Efficiency	High	High	Normal	Normal
System Footprint	Low	Normal	High	Very high
OS support	Any multi-tasks operating system like Vxworks, UbiFOS, OSE, ThreadX, Linux/uClinux are being supported.	Linux	DOS, Linux, QNX	Linux

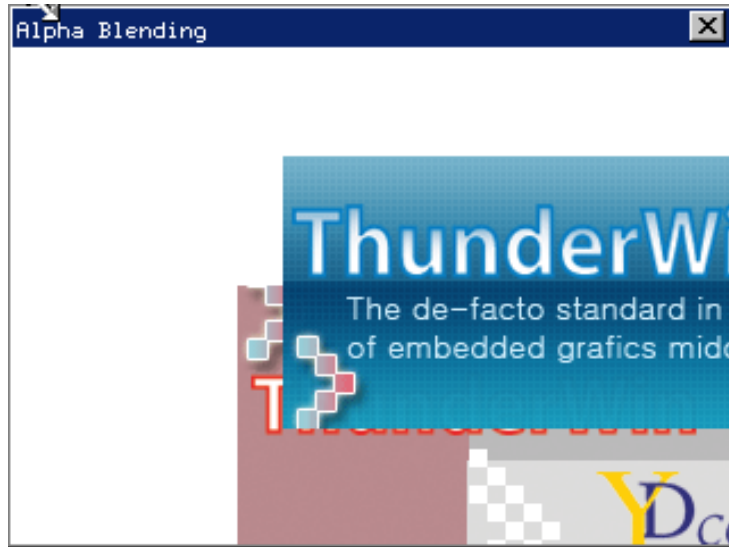
- <http://www.gnu.org/software/libc/>
- License: LGPL
- C library from the GNU project
- Designed for performance, standards compliance and portability
- Found on all GNU / Linux host systems
- Quite big for small embedded systems: about 1.7 MB on Familiar Linux iPAQs (libc: 1.2 MB, libm: 500 KB)



- <http://www.uclibc.org/> for CodePoet Consulting
- License: LGPL
- Lightweight C library for small embedded systems, with most features though.
- The whole Debian Woody was ported to it...You can assume it satisfied most needs!
- Size (arm): 4 times smaller than glibc! uClibc: approx. 400 KB (libuClibc: 300 KB, libm: 55KB) glibc: approx 1700 KB (libc: 1.2 MB, libm: 500 KB)

<i>C program</i>	<i>Compiled with shared libraries</i>		<i>Compiled statically</i>	
	<i>glibc</i>	<i>uClibc</i>	<i>glibc</i>	<i>uClibc</i>
Plain "hello world"	4.6 K	4.4 K	475 K	25 K
Busybox	245 K	231 K	843 K	311 K





qvfb용도

The virtual framebuffer allows ThuderWin programs to be developed on your desktop machine, without switching between consoles and X11.

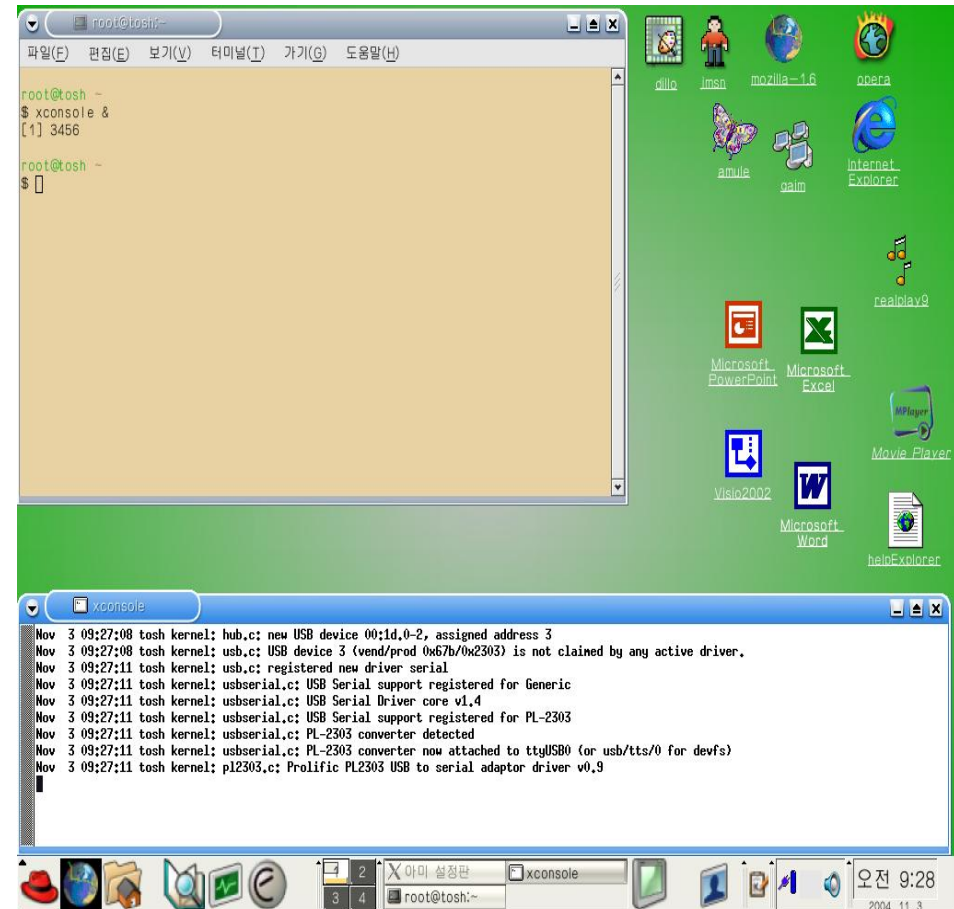
wvfb용도

The virtual framebuffer allows ThuderWin programs to be developed on your M\$ desktop machine.



- ‘GNU’가 무료라면 아무도 그것을 사용하지 않을 것이다. 왜냐하면 무료라는 것은 어떠한 지원도 기대할 수 없다는 것을 의미하기 때문이다.”
- “지원 서비스를 제공하기 위해서는 프로그램에 비용을 부과해야만 한다.”
- “프로그래머는 밥줄이 끊기지 않을까?”
- “경쟁을 통해서 보다 나은 결과를 얻을 수 있다.”
- “금전적인 특혜가 없다면 아무도 프로그래밍을 하지 않을 것이다.”
- “창작자는 창작물의 사용을 통제할 권리를 갖고 있지 않은가?”

1. /etc/syslog.conf 편집
kern.* /dev/console
2. xconsole 실행
3. \$ tail -f /var/log/messages



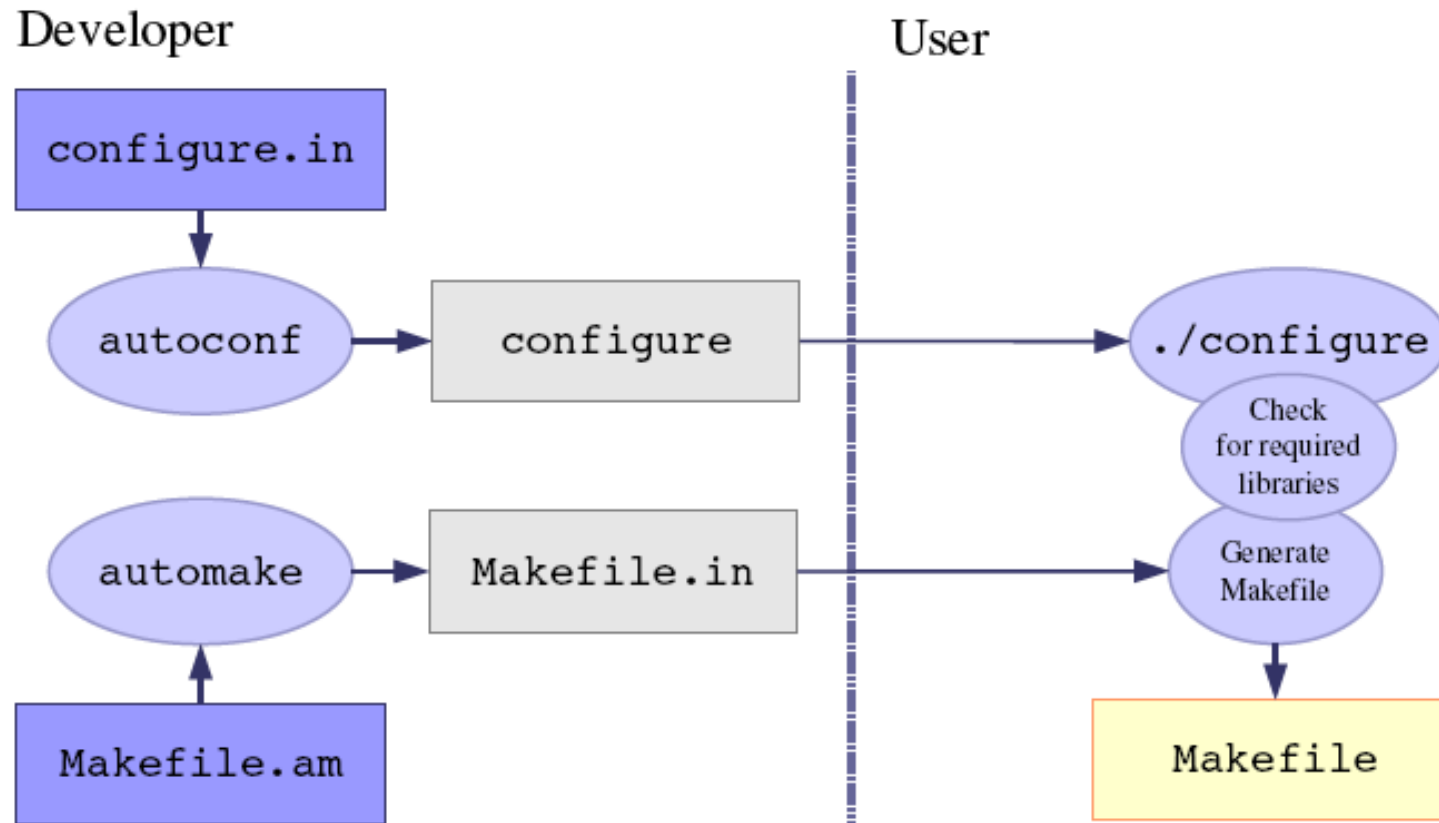
Section 3

"There's more than one way to do it"

- Larry Wall

- How to port library or applications
- autoconf / automake
- uClinux
 - What is it?
 - uClinux devices
 - Linux vs. uClinux
 - Limitations of uClinux
- Trend of embedded Linux

- Manually port
 - Modify makefile
 - Change header and C/C++ files
- Use automake / autoconfig tools
- ❖ It depends on the portability of code
- ❖ Programmer must understand OS and H/W



- Name

Pronounced "youseelinux", the name uClinux comes from combining the greek letter "mu" and the english capital "C". "Mu" stands for "micro", and the "C" is for "controller".

- Linux for processors that have no memory management
- targets classic embedded 32bit microcontrollers
- modifications to standard Linux kernel source





Sigma Designs EM85xx, 862x, 8634
DVD, DivX player and IP-STB

Multimedia



Apple iPod (not shipped with uClinux)

Tiny Single Board Computers



C Data Solutions
CF computer

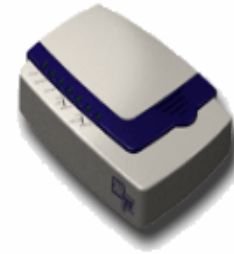
Simtec SBCs

Industrial



IntelliCom remote control system

Network devices



SnapGear LITE2 VPN/Router



picotux RJ45 size
computer

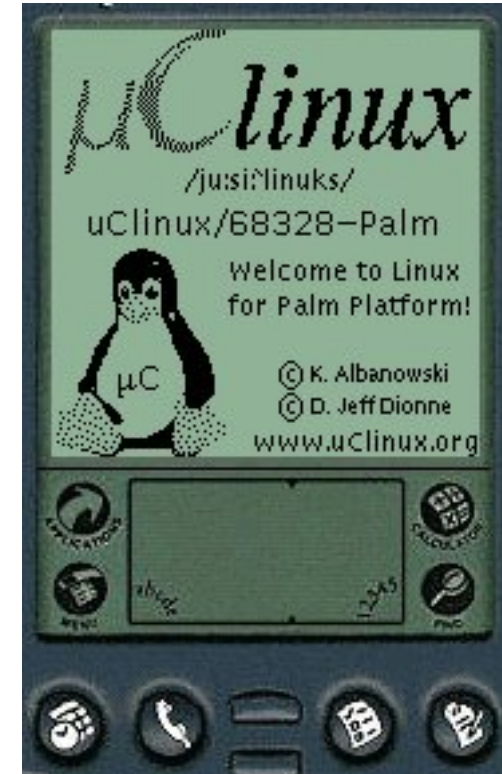


StarDot NetCam

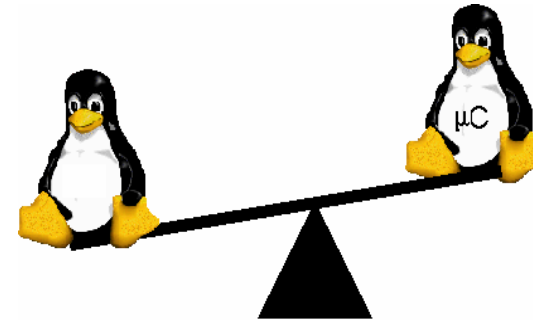
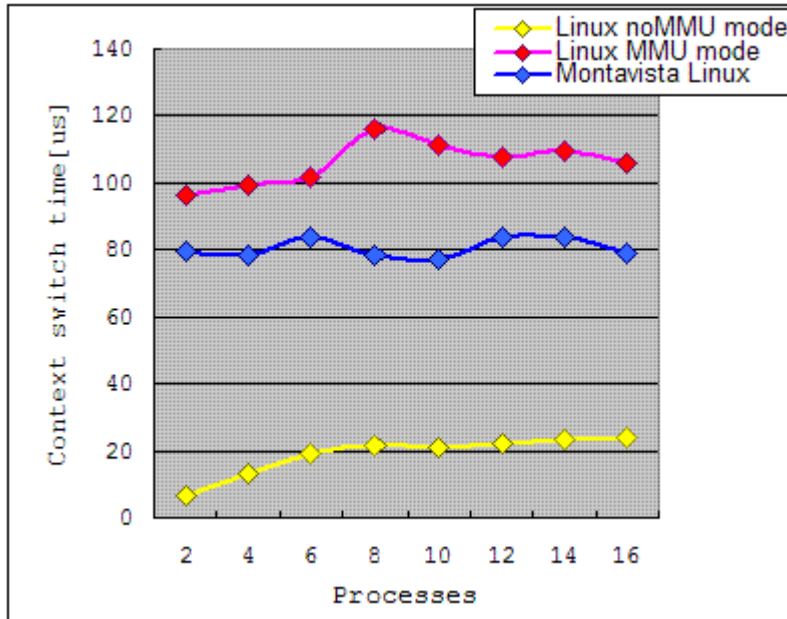


Aplio/PRO IP Phone

- First release in 1998 (Linux 2.0), for the Motorola 68000 processor. Demonstrated on Palm Pilot III.
- 1999: Motorola ColdFire support
- 2001: Linux 2.4 support. ARM7 support
- 2004: Linux 2.6 support for ARM
- 2007: You're reading this document



- CheaperMMU-less arm cores are smaller.
- SufficientA large number of embedded systems applications can do without an MMU.
- FasterFaster context switches: no cache flushes.
- LightweightFull Linux 2.6 kernel under 300K, binaries much smaller with uClibc.
- XIP (Execute In Place)Don't have to load executables in RAM. May run slower though.



< Context switch time >

	Linux-2.6.11.6	uClinux-2.6.11.6	Linux-2.4.20-mvista
lat_fifo(us)	200.28	37.89	134.01
bw_pipe(MB/s)	(*12.58) 20.95	22.47	13.89

(*) was the result of Linux-2.6.7.

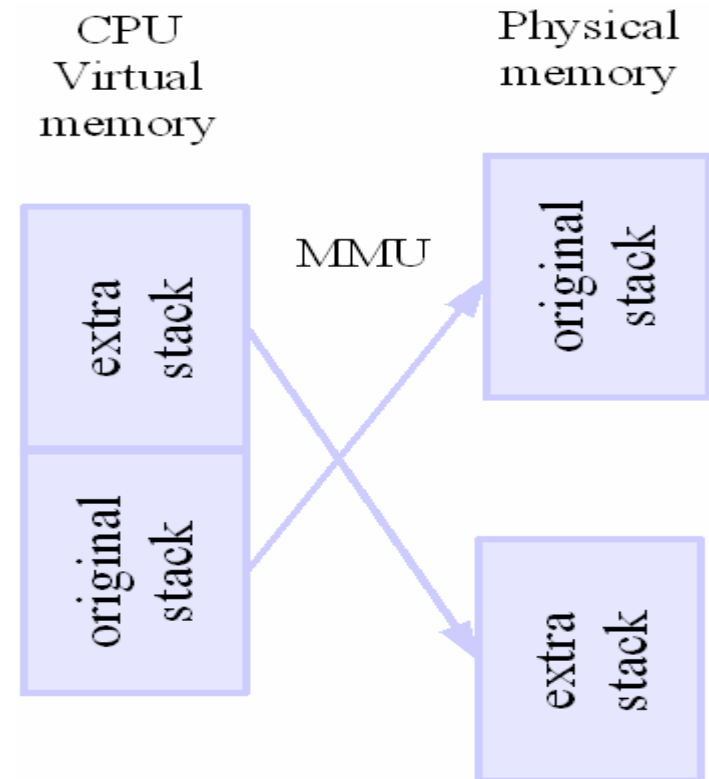
< IPC performance >

- no virtual memory
- no memory protection
typically between kernel, processes or hardware devices!
- no real *fork()*, only *vfork()* and *clone()*
- cannot dynamically grow stacks
- no conventional *sbrk()*
- memory fragmentation more of a problem

- Standard formats (such as ELF) rely on VM to create the address space of a process.
- flat format: condensed executable format storing only executable code and data, plus the relocations needed to load the executable into any location in memory.
- uClinux specific toolchains are needed to create executables in this format.
- mmap function
 - Only read-only mappings can be shared (no copy-on-write) without allocating memory.

Linux

- With VM, can grow the stack of a running process whenever needed.
- Whenever an application tries to write beyond the top of its stack, the MMU raises an exception. This causes some new memory to be allocated and mapped in at the top of the stack.



RTOS

`taskSpawn (name, priority, options, stacksize, main, arg1, ...arg10);`

- uClinux
- Stack size must be allocated at compile time: 4 KB by default.
- No exception raised when a process writes beyond the top of its stack! The consequences of this could surface much later.
- If strange crashes happen, try to increase the stack size of programs:
 - Either recompile: `run export FLTFLAGS=-s <stacksize>` before recompiling.
 - Or run `flthdr -s <stacksize> <executable>`

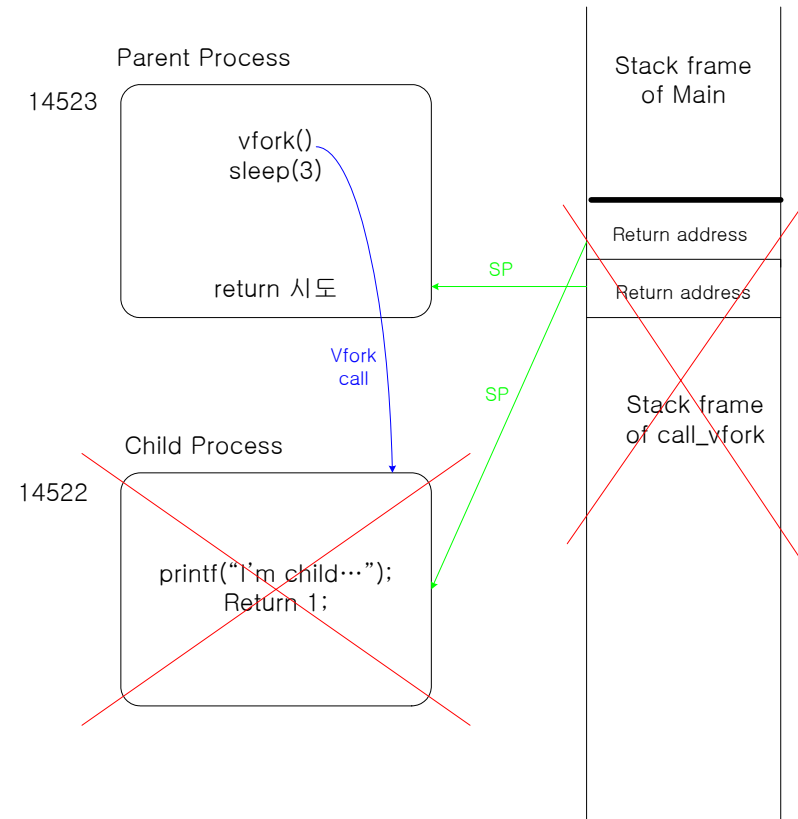

```

DDD: /home/cody/study/vfork/vfork_err.c
File Edit View Program Commands Status Source Data Help
0: |
23 int call_vfork ()
24 {
25     pid_t pid;
26
27     pid = vfork ();
28     if (pid < 0)
29         fprintf (stderr, "vfork error. errno = %d \n", errno);
30     else if (0 == pid) // child process
31     {
32         printf ("I'm child. My PID is %d \n", getpid ());
33         return 1; // return stack frame to OS
34     }
35     // parent process
36     else
37     {
38         printf ("I'm parent. My PID is %d \n", getpid ());
39         sleep (3);
40     }
41     return 0;
42 }
43
44 int main (void)
45 {
46     printf ("Before vfork. \n");
47     call_vfork ();
48     printf ("After call vfork in fuction, my PID is %d \n", getpid ());
49     return 0 ;
50 }
51
52
53 }

GNU DDD 3.3.1 (i386-redhat-linux-gnu), by Dorothea L(gdb) run
Before vfork.
I'm child. My PID is 14802
After call vfork in fuction, my PID is 14802
I'm parent. My PID is 14801

Program received signal SIGSEGV, Segmentation fault.
0x42130a16 in __DTOR_END__ () from /lib/tls/libc.so.6
(gdb) break vfork_err.c:27
Breakpoint 1 at 0x8048461: file vfork_err.c, line 27.
(gdb)

```



- Chose the specific MiniGUI port depends on OS like Linux, uClinux and VxWorks, UbiFOS
- Build by the cross-compiler
- Change sources relations with output and input device
- Run example programs

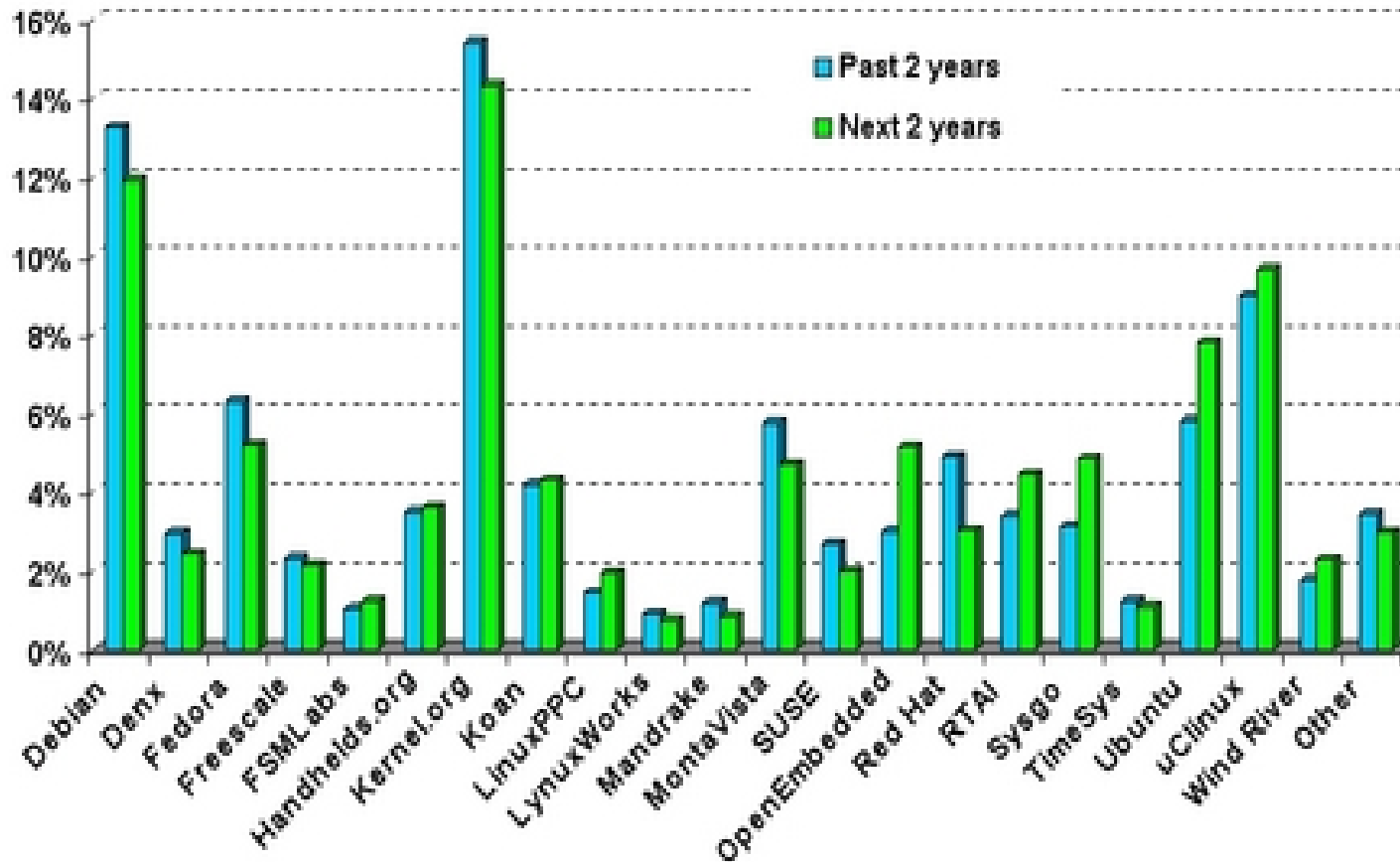
1. But all processors will have MMUs soon?

Many vendors still developing new silicon
Price/complexity lower

2. But it is not real Linux right?

Get linux2.6.20 and compile for nonMMU,
how can you get more Linux than that!

Embedded Linux OS sourcing trends



Ref) LinuxDevices.com, April 2007 year

Section 4

'Given enough eyeballs, all bugs are shallow'^{6,7}

- In 'cathedral bazaar'

- Standard Digital TV
- Set top box
 - 위성/Cable
 - IP STB
 - Hybrid STB
 - Convergence STB
- Middle ware : ACAP, MHP
- Embedded browser
- DLNA
- OSGi / Havi
- Optimization

Parameter	US (ATSC)	Europe, Asia (DVB)	Japan (ISDB)	OpenCable™
video compression	MPEG-2			
audio compression	Dolby® Digital	MPEG-2, Dolby® Digital, DTS®	MPEG-2 AAC-LC	Dolby® Digital
multiplexing	MPEG-2 transport stream			
terrestrial modulation	8-VSB	COFDM	BST-OFDM ²	-
channel bandwidth	6 MHz	6, 7, or 8 MHz	6, 7, or 8 MHz	6 MHz
cable modulation	16-VSB ³	QAM	QAM	QAM
channel bandwidth	6 MHz	6, 7, or 8 MHz	6, 7, or 8 MHz	6 MHz
satellite modulation	QPSK, 8PSK	QPSK	PSK	-

	CCIR-601 525/60(NTSC)	CCIR-601 625/50(PAL/SECAM)	CIF	QCIF
Luminance Resolution	720x480	720x576	352x288	176x144
Color Subsampling	4:2:2	4:2:2	4:2:0	4:2:0
Fields/sec	60	50	30	30

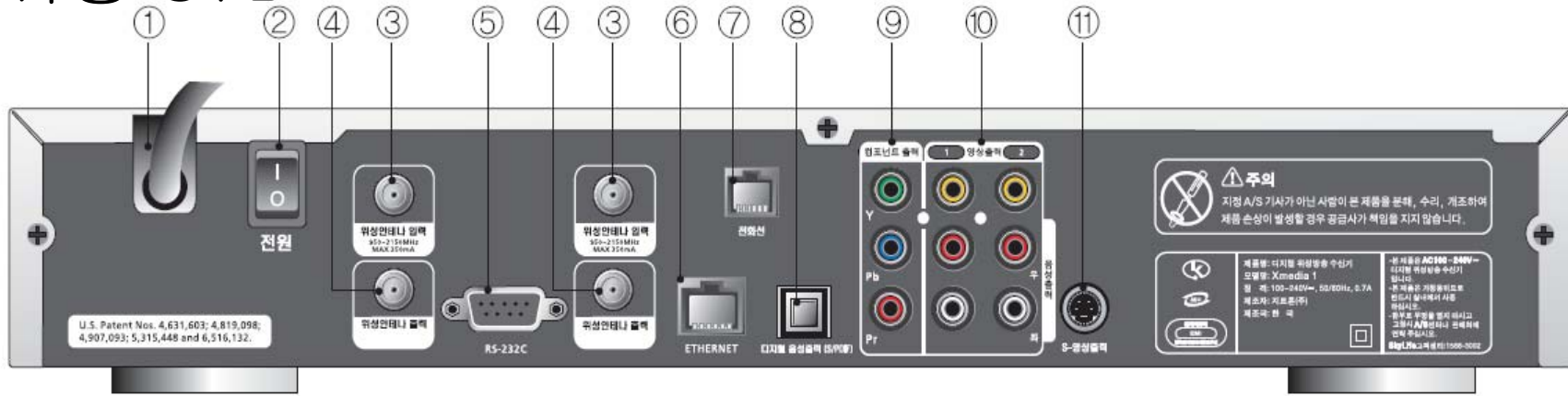
구 분	아날로그 TV	디지털 TV	
		SDTV	HDTV
주사선수	525개	704*480i or 576i ¹⁾	1920*1080i or p ²⁾
해상도	약 330선	700선 이상	
음 질	2채널 FM 스테레오	5.1 멀티채널	
화면비(가로*세로)	4 : 3	4 : 3 또는 16 : 9	16 : 9
부가기능	문자다중방송, VBI를 이용한 데이터방송	홈쇼핑, 홈뱅킹, 인터넷 접속, 전자투표 등 양방향 방송 가능	

1) interlace 2) progressive

- OpenCable : digital cable standard for America, Republic of Korea
- ATSC (Advanced Television Systems Committee) : digital broadcast standard for America, Republic of Korea, Canada, Taiwan and Argentina
- DVB (Digital Video Broadcast) : digital television broadcast standard for Europe and many countries
- ISDB (Integrated Services Digital Broadcasting) : digital television broadcast standard is used in Japan

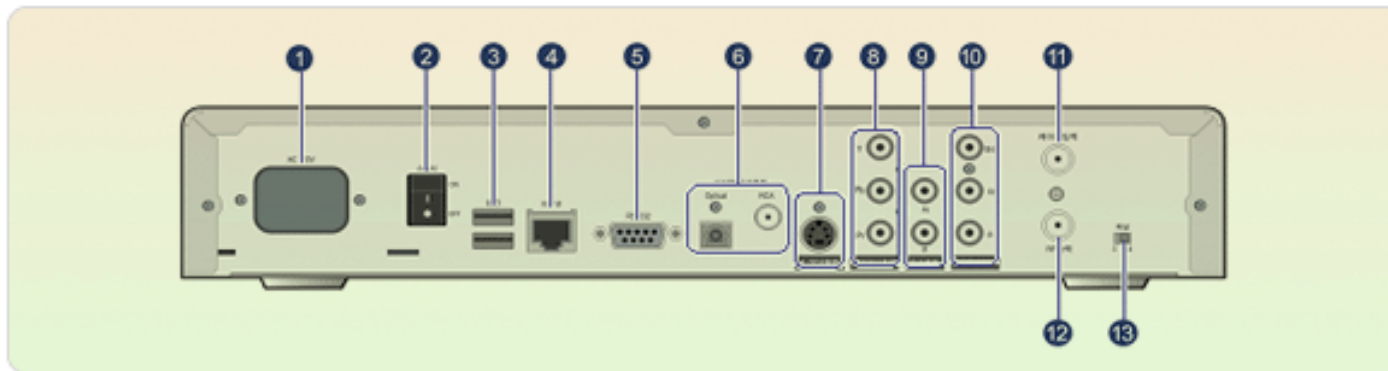
- 지상파 : ATSC , ACAP
 - Cable : OpenCable, OCAP + Internet
 - 위성 : DVB-S, MHP
-
- ❖ 참고 : DVB 표준 범위
 - DVB-T (Terrestrial)
 - DVB-C (Cable)
 - DVB-S (Satellite)
 - DVB-S2 (Satellite 2)
 - DVB-H (Handheld)

위성 STB



Cable STB

➔ 셋톱박스 후면부

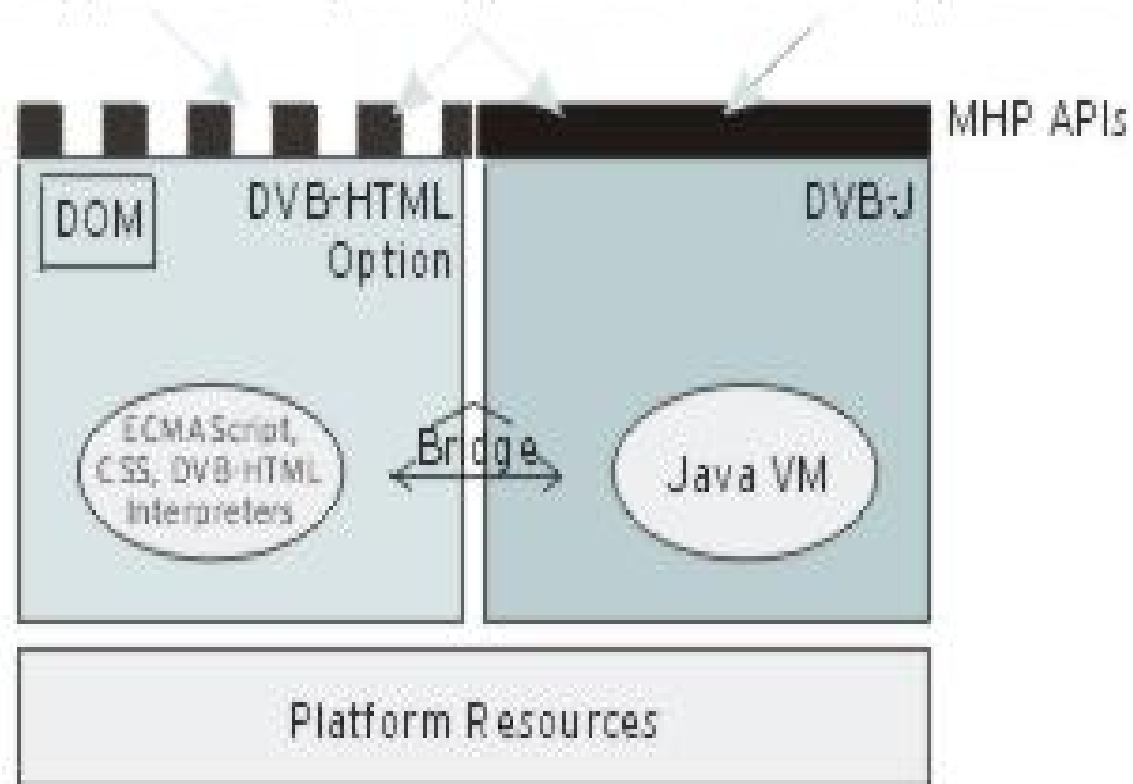


- Pure IP-STB
- Hybrid IP-STB
 - 지상파 + IP-STB
 - Cable + IP-STB
 - 위성 + IP-STB
- Multimedia player
 - DivX player
 - DMA / DMP
- convergence STB
 - Multimedia player + IP-STB
 - DVD + IP-STB

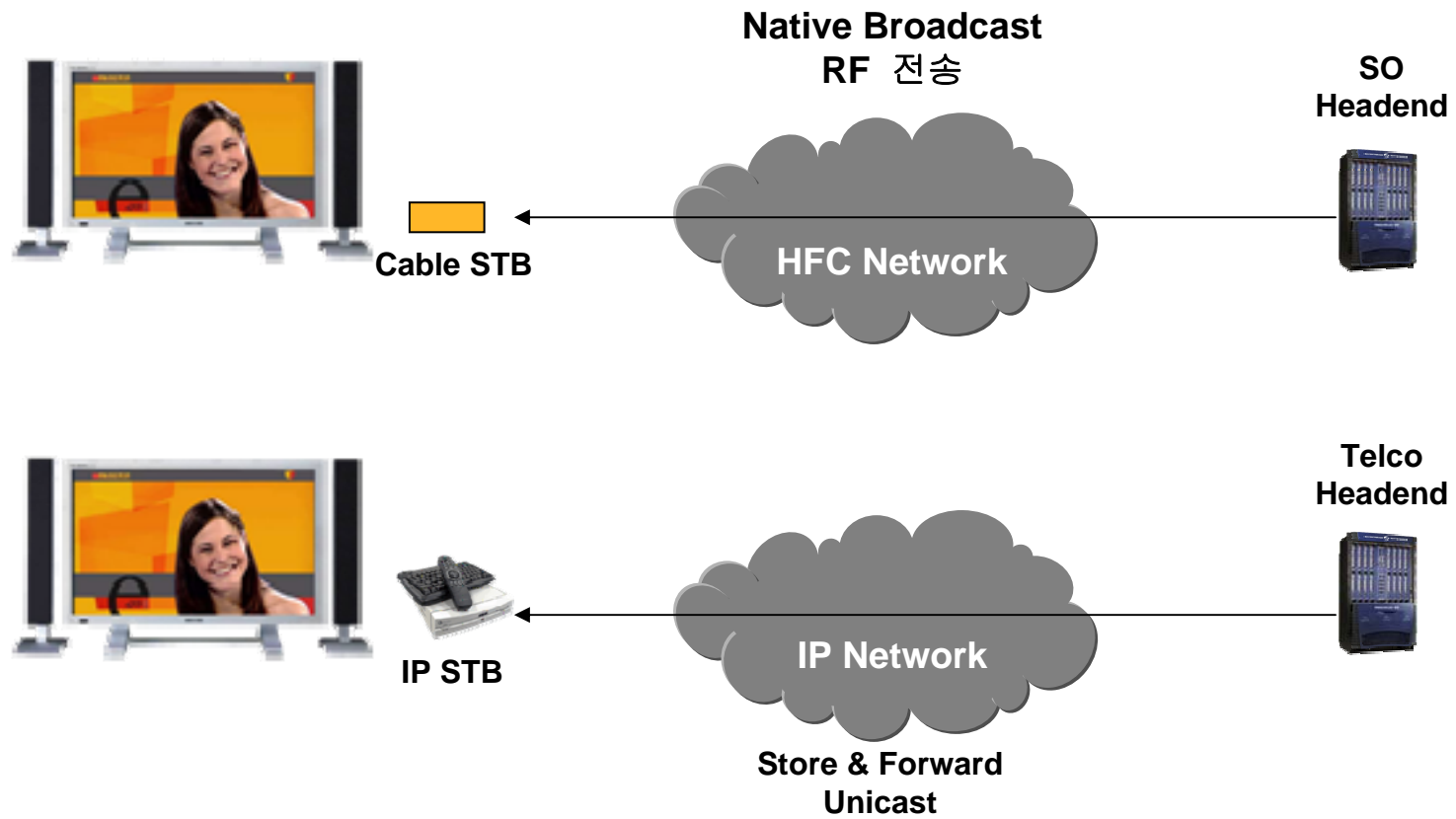


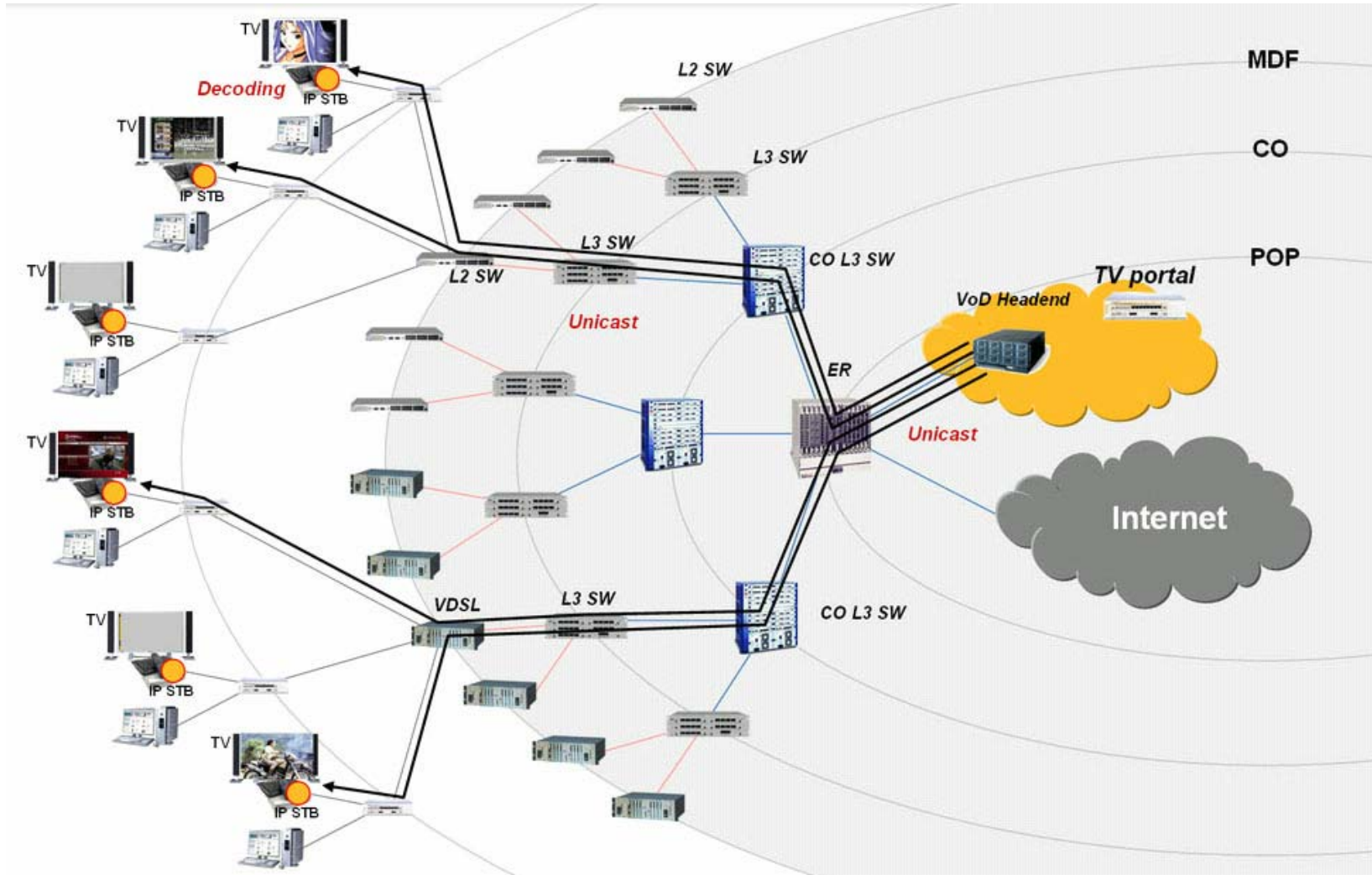
- MHP (Multimedia Home Platform)
 - DVB (Digital Video Broadcasting) 산하의 디지털 데이터방송 표준 규격
 - 국내 위성 방송에서 채택
- OCAP (OpenCable Application Platform)
 - 케이블TV 방송에서의 양방향 서비스를 위한 어플리케이션 제작 기반이 되는 표준
 - OCAP 1.0은 DVB-MHP1.0.1을 기반으로 하여 북미 케이블 TV 방식에서 요구되는 사항들을 보강하여 만들어짐
 - 국내 케이블 방송에서 채택
- ACAP (Advanced Common Application Platform)
 - 북미에서 지상파와 케이블TV의 콘텐츠 호환성을 고려하여 DASE* 와 JAVA 기술을 기반으로 OCAP 기술을 추가하여 발전시킨 데이터방송 표준
 - * DASE(Digital TV Applications Software Environment standard): ATSC middleware 표준
 - 국내 지상파 방송에서 채택

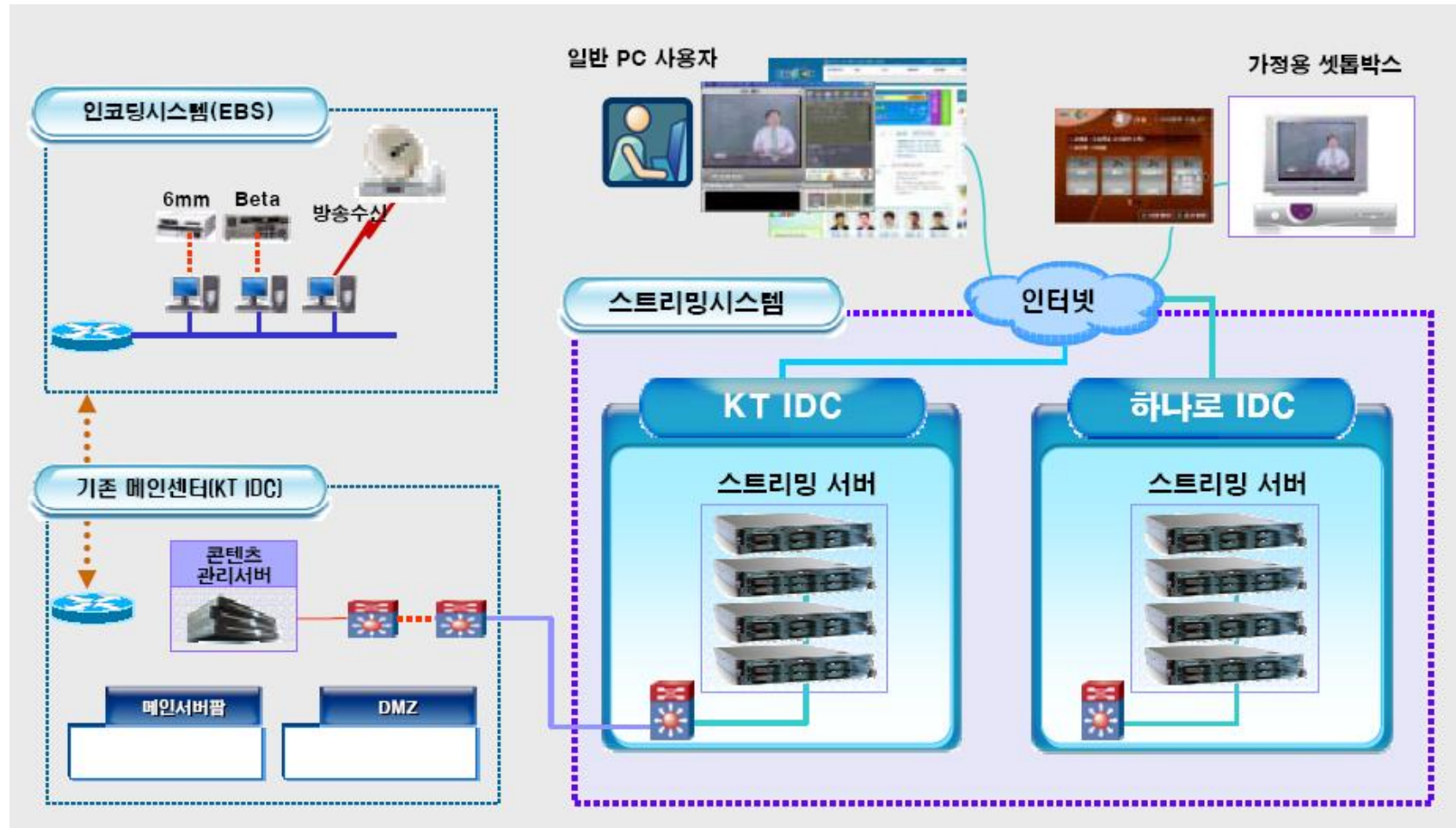
DVB-HTML Applications Hybrid Applications DVB-J Applications

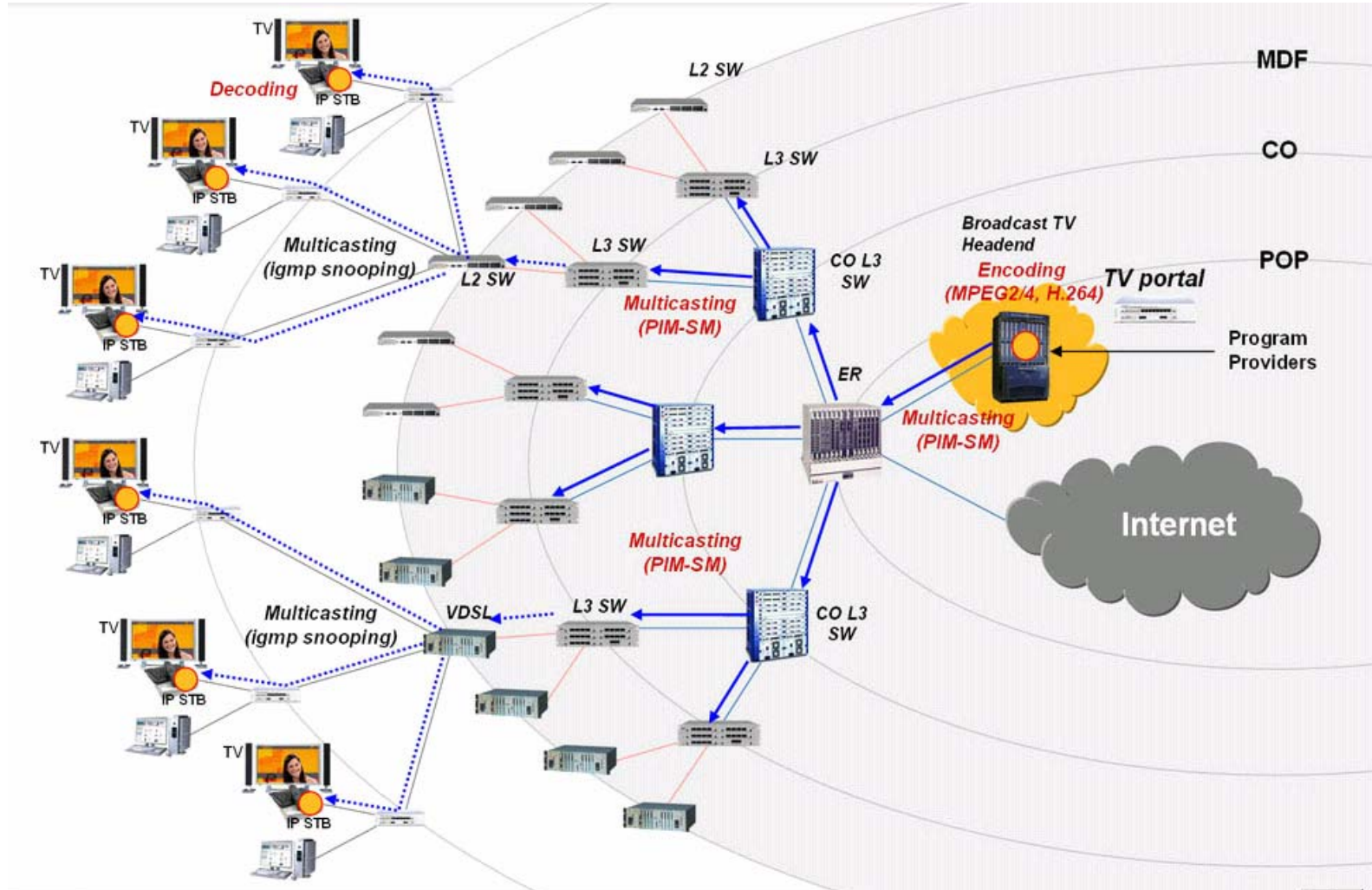


MHP 11 Basic Architecture











■ Browser

웹 브라우저	HTTP	HTTP 1.1
	HTML	HTML 4.01
	CSS	CSS level 2
	XML	XML 1.0
	DOM	DOM level 2
	JavaScript	ECMA-262
	SSL	SSL 3.0
	Plug-in API	Plug-in API

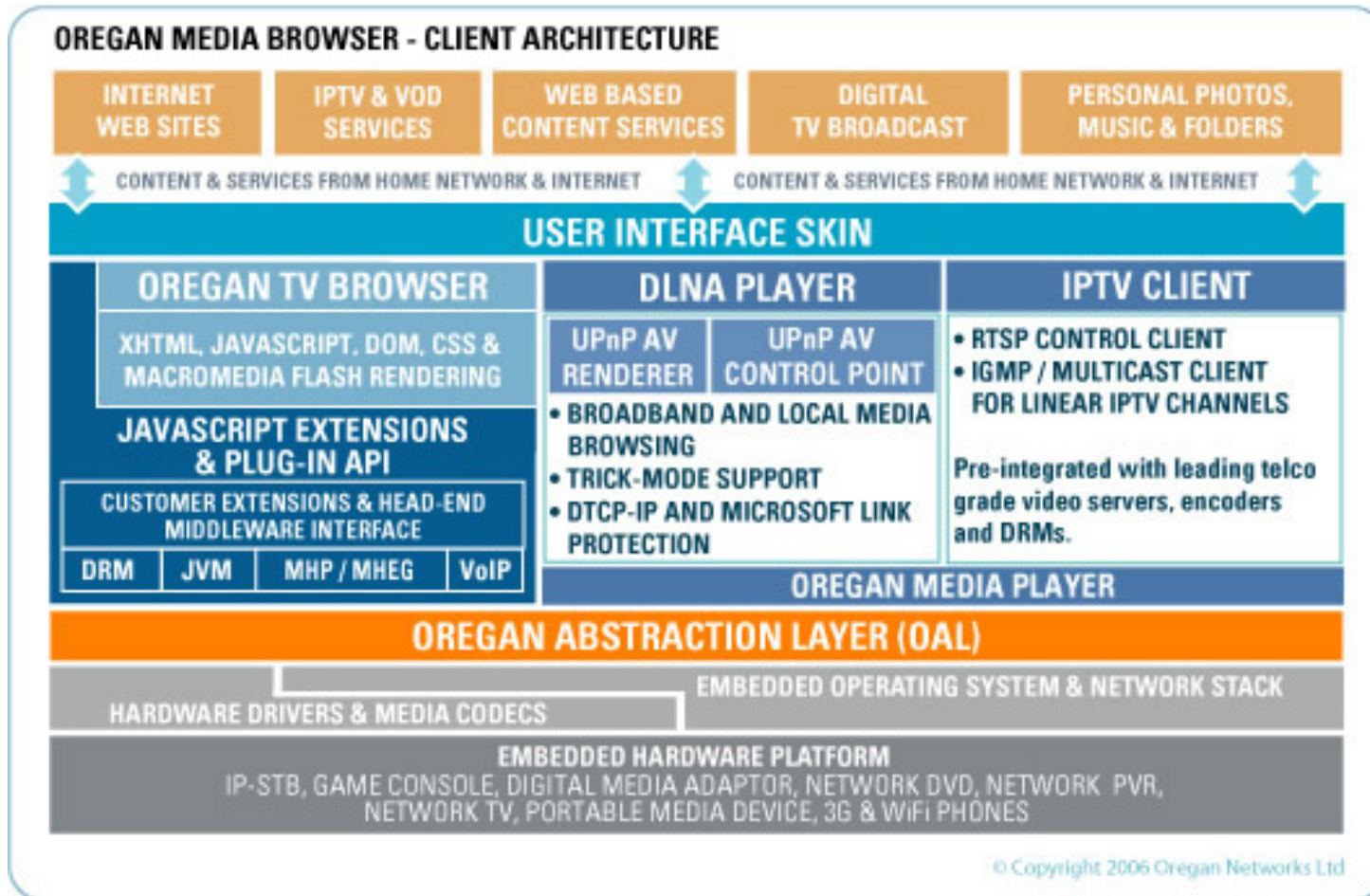
■ Streaming and protocol

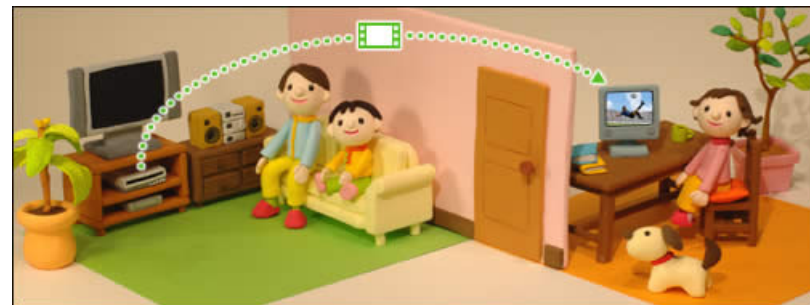
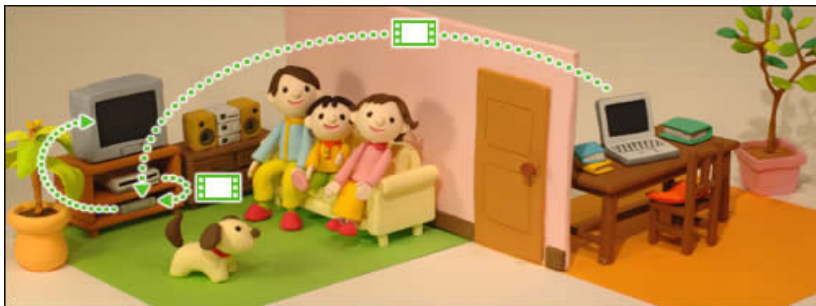
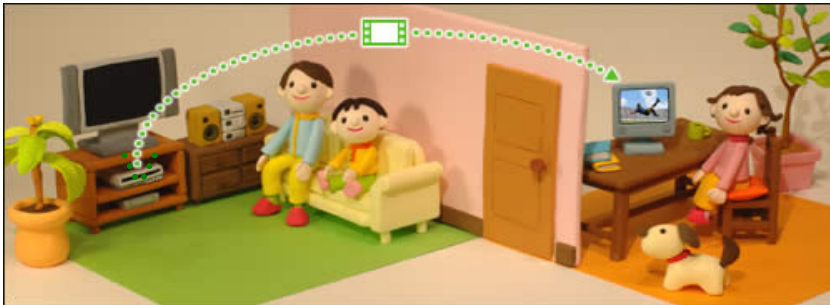
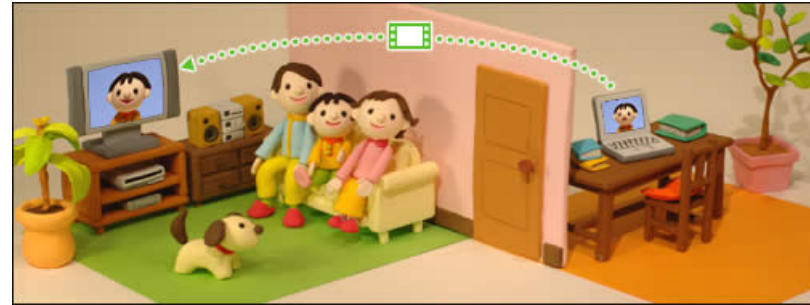
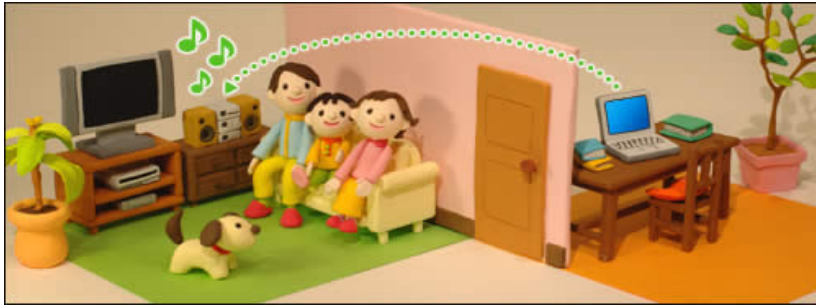
스트리밍 프로토콜	파일 포맷	프로파일 0 : MP4 프로파일 1 : MPEG-2 TS
	비디오 코덱	프로파일 0 : H264, MPEG-4 ASP 프로파일 1 : MPEG-2
	오디오 코덱	프로파일 0 : MP 3, MPEG-4 AAC 프로파일 1 : MPEG-2, AC-3
	미디어 제어 프로토콜	RTSP, SDP
	미디어 전송 프로토콜	RTP, UDP/TCP
	RTP Payloads	미 정의

- Contents driven user interface
 - Update contents : VOD titles
 - 부가 정보 서비스 : 날씨, 주식, 교통정보

- Open standard
 - Easy to develop data service
 - Not proprietary

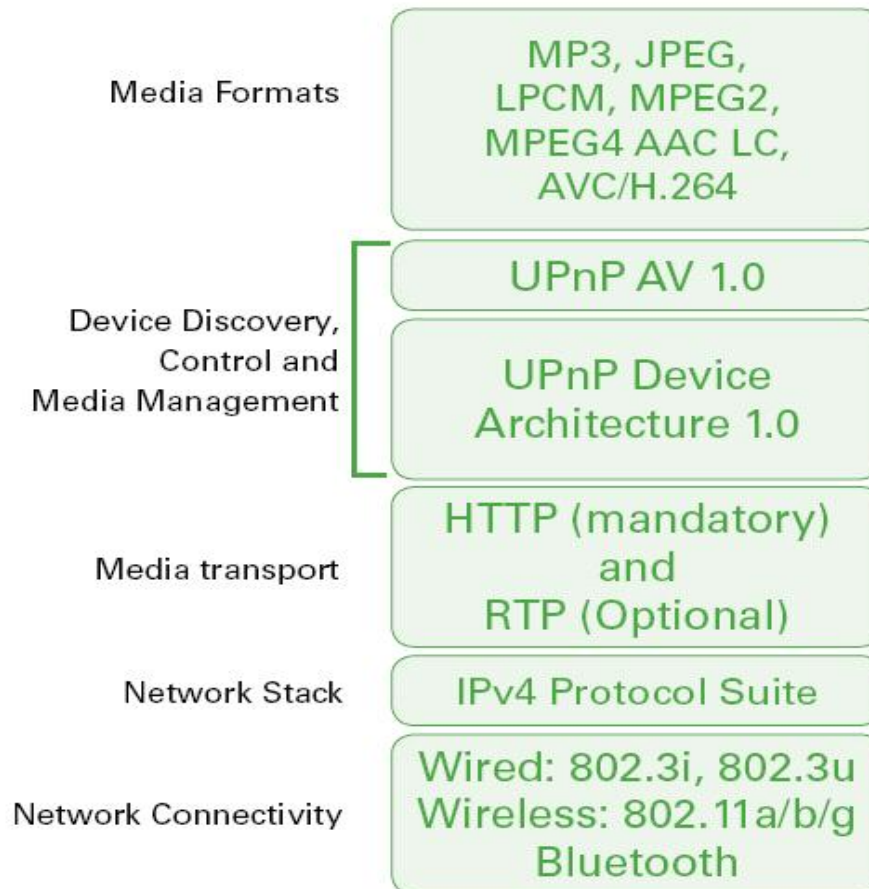




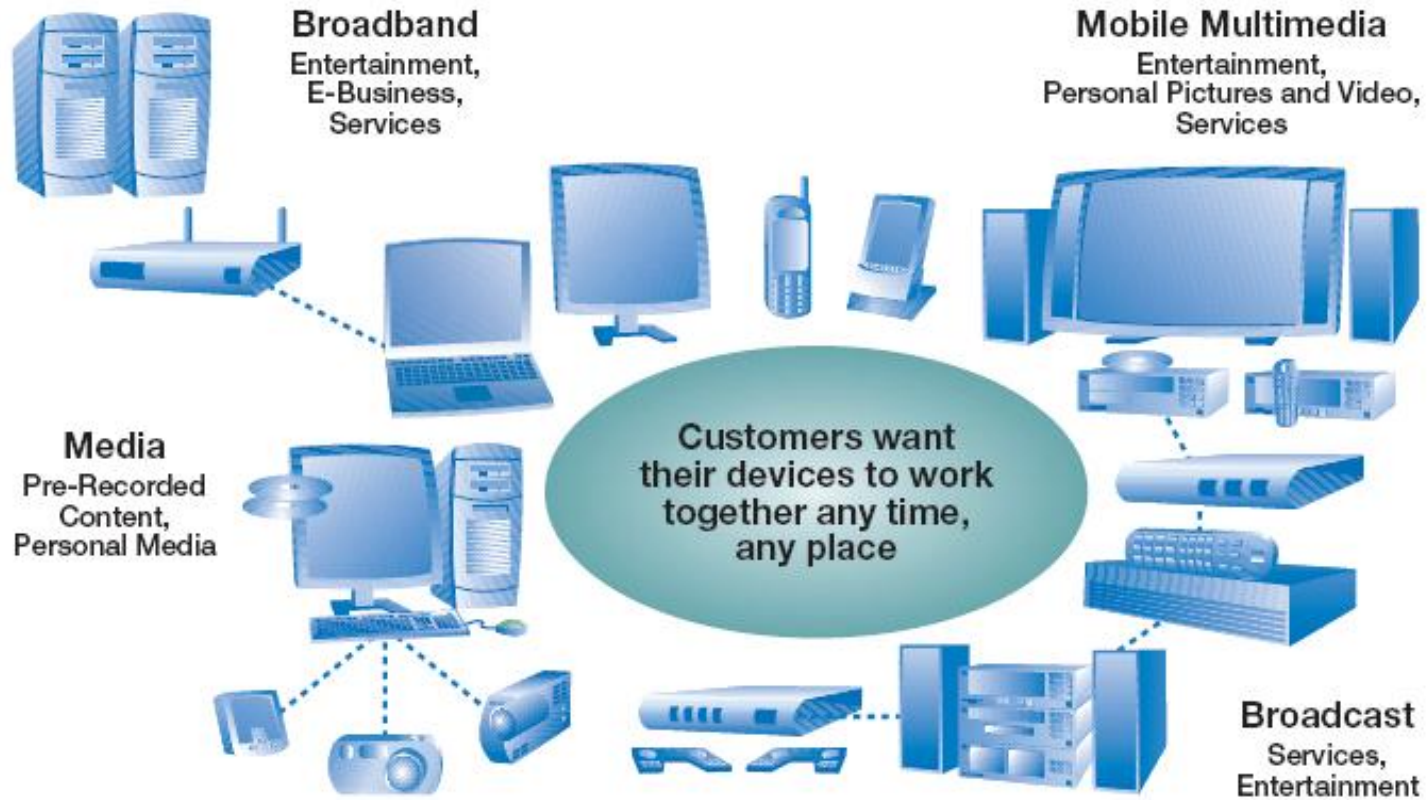




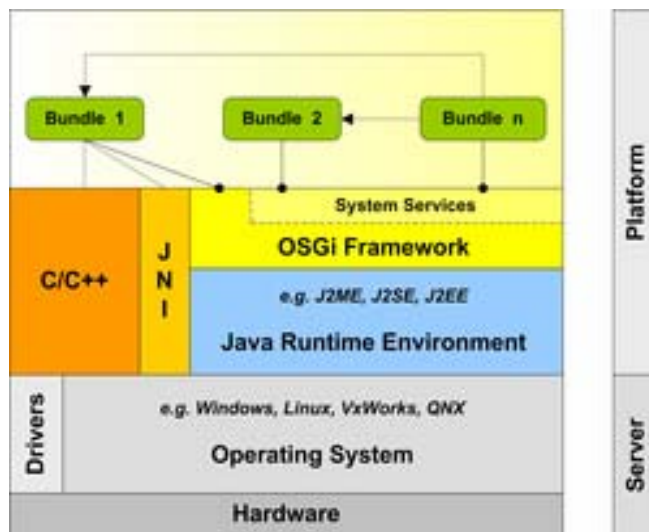
DLNA Interoperability Guidelines Building Blocks







- Open Services Gateway initiative
- Alliance and its members have specified a Java-based service platform that can be remotely managed.



- Home Audio Video Interoperability (HAVi) is a connection to control Audio and Video hardware using FireWire(ieee1394)



- Increasing speed
- Reducing size: disk footprint and RAM
- Reducing power consumption
- Global perspective: cost and combined optimization effects=

- The output of kernel bootup messages to the console takes time! Even worse: scrolling up in framebuffer consoles! Console output not needed in production systems.
- Console output can be disabled with the quiet argument in the Linux kernel command line (bootloader settings)
- Example:
`root=/dev/ram0 rw init=/startup.sh quiet`
- Benchmarks: can reduce boot time by 30 or even 50%!



- Implemented as file system drivers that plug into the Linux VFS architecture
- Lots of these! For desktop users, the following may be familiar:
 - 예) ext3, ReiserFS, NTFS, FAT, minix, ...
- Embedded Systems typically use specialized file systems
 - romfs
 - ext2
 - cramfs
 - JFFS2
 - squashfs
 - YAFFS2
 - ...

Description	Minimum filesystem, very small kernel module. The “rom” in romfs doesn’t refer to the hardware “ROM”.
When to Use	<ul style="list-style-type: none">▪ Trying to make as compact a kernel as possible▪ Initial RAM disks
Capacity and Limitations	All files owned by root Read-only No compression
How to Use	<pre>\$ genromfs -f ./romfs-rfs/rfs -d \$RFS</pre> <p>Create filesystem with mkromfs utility. Creating device nodes particularly interesting – create a file starting with @ with device node information. Example: @console,5,1</p>
Home Page More Info	<kernel>/Documentation/filesystems http://romfs.sourceforge.net/ http://lldn.timesys.com/docs/tiny flash

Description	Compressed ROM Filesystem. Read only filesystem widely used in the embedded space. Data stored in compressed format (zlib).
When to Use	<ul style="list-style-type: none">▪ Low-memory systems▪ Ensures RFS integrity▪ Metadata not important (doesn't store full information)
Capacity and Limitations	256 MB, 2 ¹⁶ files Does not store all permissions, all files owned by root. No timestamps stored (inode overhead is just 12 bytes!)
How to Use	<pre>\$ mkcramfs -m dev.cramfs.txt <rfs_dir> rootfs.cramfs</pre> <p>Full details at: http://l1dn.timesys.com/docs/cramfs</p>
Home Page More Info	http://sourceforge.net/projects/cramfs http://l1dn.timesys.com/tag/cramfs

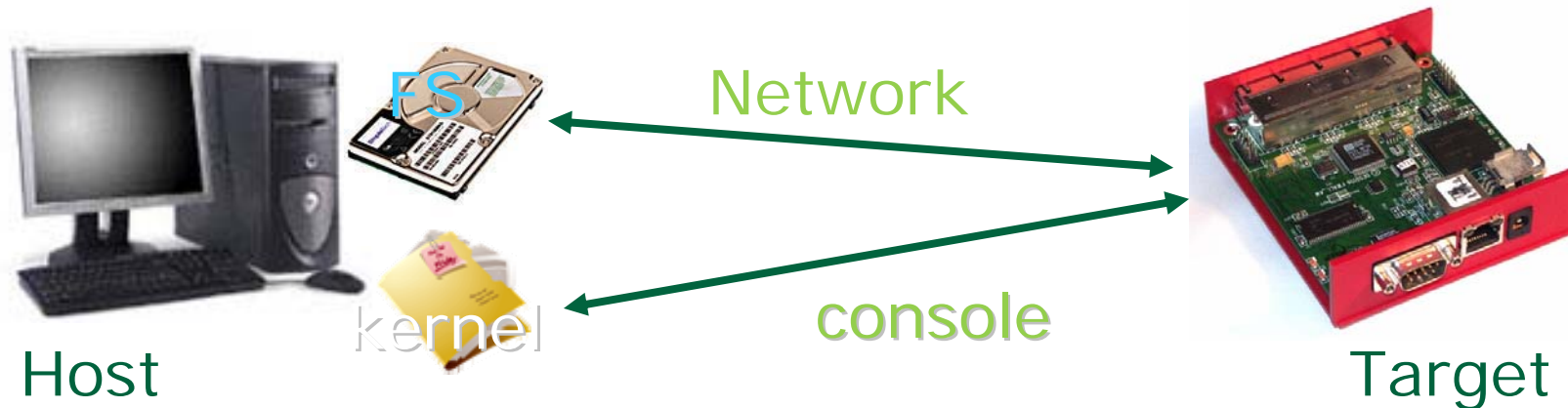
Description	Read only filesystem that includes several improvements over cramfs, notably in compression and metadata storage. Adjustable block sizes allow a user to create filesystems that compress better.
When to Use	<ul style="list-style-type: none">▪ Low-memory systems▪ Need control over the endianness
Capacity and Limitations	2 ³² GB, 2 ³² files, Page size from 2 ¹² to 2 ¹⁸ A files owned by root Read-only
How to Use	<pre>\$ mksquashfs \$RFS ./squashfs-rfs/rfs -nopad -all-root</pre> <p>The resulting file can then be written directly to a flash partition. Use <code>rootfstype=squashfs</code> on the command line, mounting the <code>/dev/mtdblock</code> device as the root device.</p>
Home Page More Info	<p>http://squashfs.sourceforge.net http://www.artemio.net/projects/linuxdoc/squashfs http://lldn.timesys.com/docs/tiny flash</p>

Description	Read/Write filesystem designed specifically for MTD/Flash based devices. Handles wear leveling and compresses data during creation and subsequent writes
When to Use	Flash-based storage hardware
Capacity and Limitations	2 ³² GB, 2 ³² files, Page size from 2 ¹² to 2 ¹⁸ Complete POSIX meta data Mounts slowly (improved lately); at capacity, writes can be slow
How to Use	<pre>\$ mkfs.jffs2 -o ../<bsp_name>-flash.jffs2 -e 00040000</pre> <p>Full details at: http://l1dn.timesys.com/docs/jffs2 rootfstype=jffs2 on the command line, mounting the /dev/mtdblock device as the root device.</p>
Home Page More Info	http://sourceware.org/jffs2 http://sourceware.org/jffs2/jffs2-html/jffs2-html.html http://l1dn.timesys.com/tag/jffs2

Description	Yet Another Flash FileSystem. Works, in principle, much like JFFS2, but designed specifically for NAND flash devices, which are a bit different than MTD flash devices.
When to Use	NAND flash devices
Capacity and Limitations	2 ³² GB, 2 ³² files Complete POSIX metadata No compression
How to Use	Filesystems created using user space tool, much like JFFS2. The resulting file can then be written directly to a flash partition.
Home Page More Info	http://www.aleph1.co.uk/taxonomy/term/31 http://www.aleph1.co.uk/node/40 http://ltdn.timesys.com/docs/tiny flash

- Integral part of 2.6 Linux kernel boot
 - A filesystem that sits on top of the kernel's inode cache
 - Looks for initramfs before using "traditional booting method"
 - Can use as "real" filesystem
- How to create
 - Part of the kernel build process
 - As a compressed cpio archive
 - `$ cd <rfs-directory>`
 - `$ find . | cpio -o -H newc | gzip > ../initramfs_data.cpio.gz`
 - Point to a directory Make `CONFIG_INITRAMFS_SOURCE` a directory name Use specification file Make `CONFIG_INITRAMFS_SOURCE` a file name that specifies what files/devices to create with what ownership permissions
- More Information
 - <http://www.timesys.com/timesource/initramfs.htm>
 - <http://lldn.timesys.com/tag/initramfs>

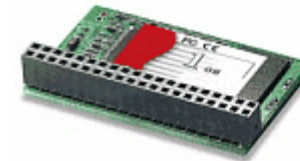
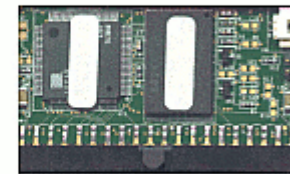
- NFS
- SMB : Server Message Block
 - M\$ → Linux
 - Linux → M\$ PC
- CIFS : Common Internet File System



- Read-only file system
 - romfs
 - cramfs
 - squashfs
- Writable file system
 - jffs2
 - yaffs2
- file system based on RAM
 - initramfs
- Network file system : nfs, smb,

- Run faster by using the most appropriate filesystems!
- Compressed readonly filesystem (block device):
 - use SquashFS (<http://squashfs.sourceforge.net>) instead of CramFS (much slower, getting obsolete).
 - NAND flash storage: if you do not need compression,
 - use yaffs2 (<http://www.aleph1.co.uk/yaffsoverview>) instead of jffs2 (much slower, consumes much more RAM).

- DOM (Disk On Module)
 - IDE/SATA interface
- CF Flash card
 - PCMCIA interface
- USB stick
- SD card
- mini SD card
- Disk On Chip



- Brooks' law
"Adding manpower to a late software project makes it later."
- Group Intercommunication Formula:
$$n(n - 1) / 2$$

example: 50 developers
 $50(50 - 1) / 2 = 1225$ channels of communication

Ref) [Fred Brooks](#), The Mythical Man-Month

- Keith Jack, Video Demystified 4th edition, LLH
- Iain E.G. Richardson, H.264 and MPEG-4 Video compression, WILEY
- www.dlna.org
- www.oregan.net
- 임베디드 SW insight
- <http://free-electrons.com>
- [Fred Brooks](#), The Mythical Man-Month
- gnu.org
- Jerry Krasner, Total Cost of Development
- Julie Giera, The Costs And Risks of Open source