HISTORY OF PERSONAL MEDIA TERMINALS: From Walkman to Apple Watch

Akihiko K. Sugiyama
Yahoo! JAPAN Research,
Yahoo Corporation

They say . . . .

The fool learn from experience

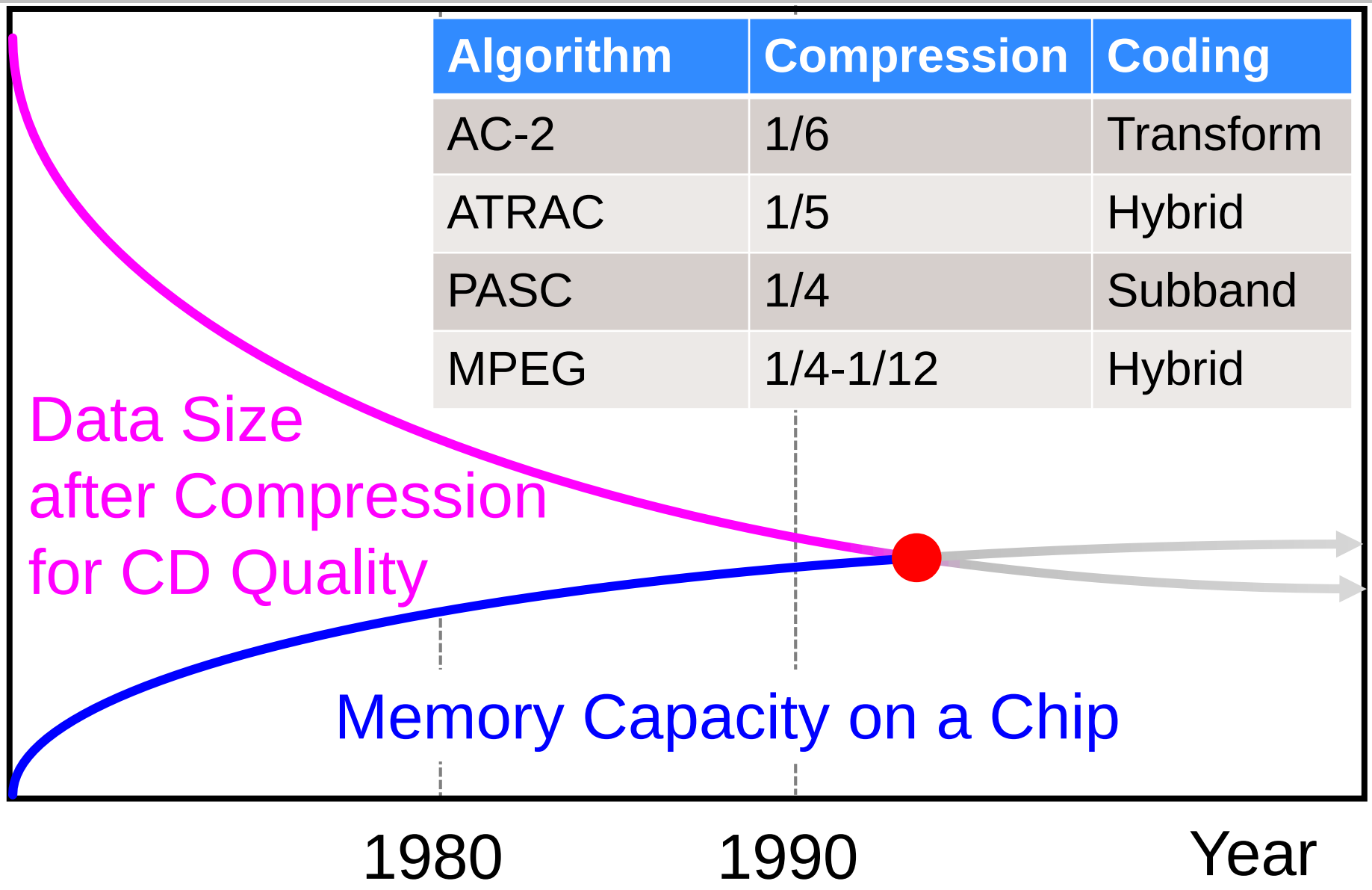
The wise learn from history

愚者は経験に学び

賢者は歴史に学ぶ

Chip Capacity vs. Data Size after Compression

Algorithm	Compression	Coding
AC-2	1/6	Transform
ATRAC	1/5	Hybrid
PASC	1/4	Subband
MPEG	1/4-1/12	Hybrid



MPEG-1: for Storage Media

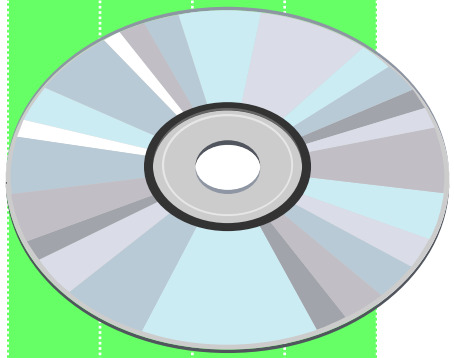
‘88 ‘89 ‘90 ‘91 ‘92 ‘93 ‘94 ‘95 ‘96 ‘97 ‘98 ‘99 ‘00 ‘01 ‘02 ‘03 ‘04 ‘05 ‘06

’92/11 Pub.

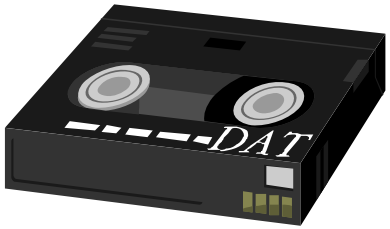
MPEG-1

’93/8

Game Terminal for TV Receivers



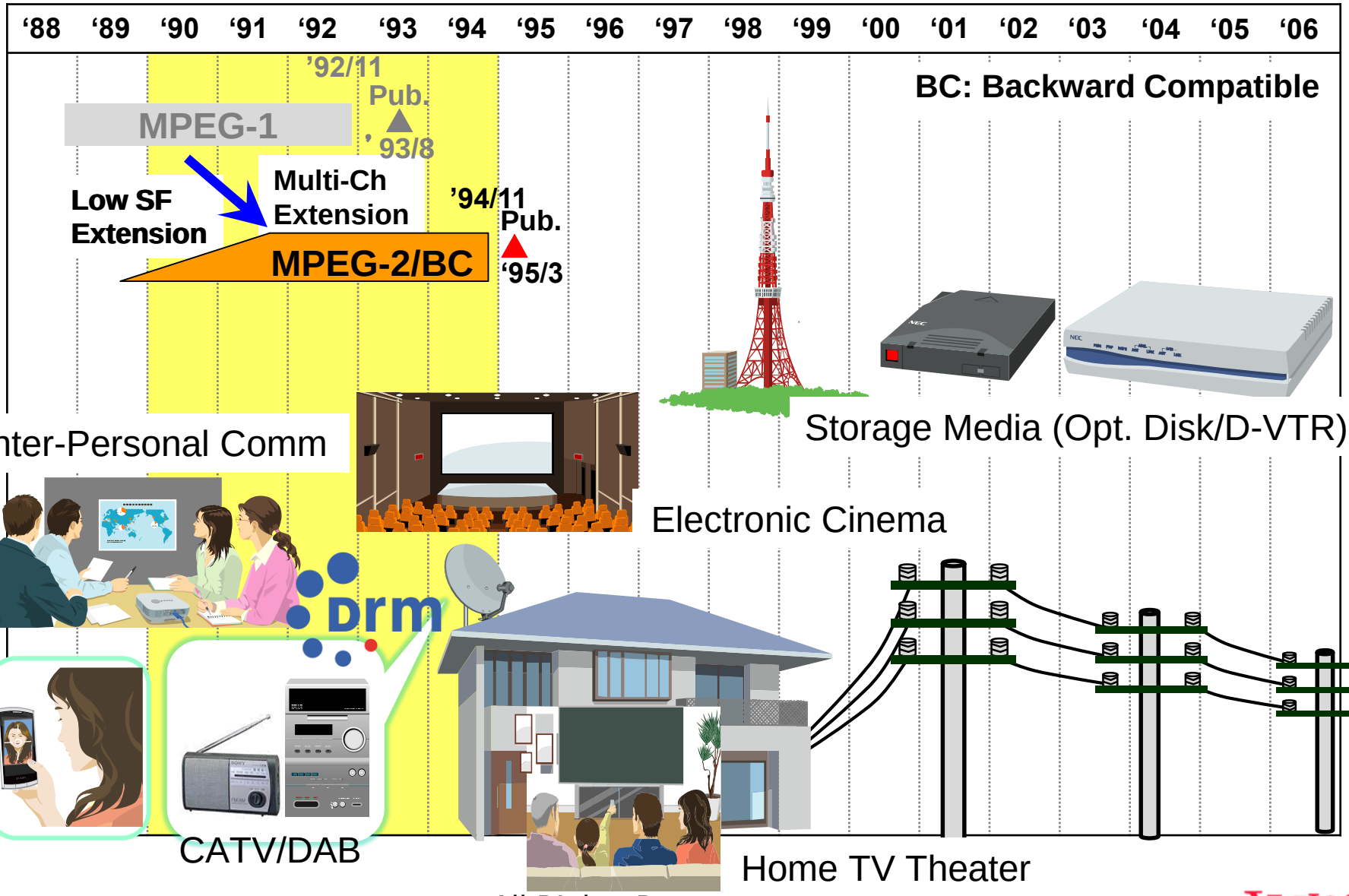
CD



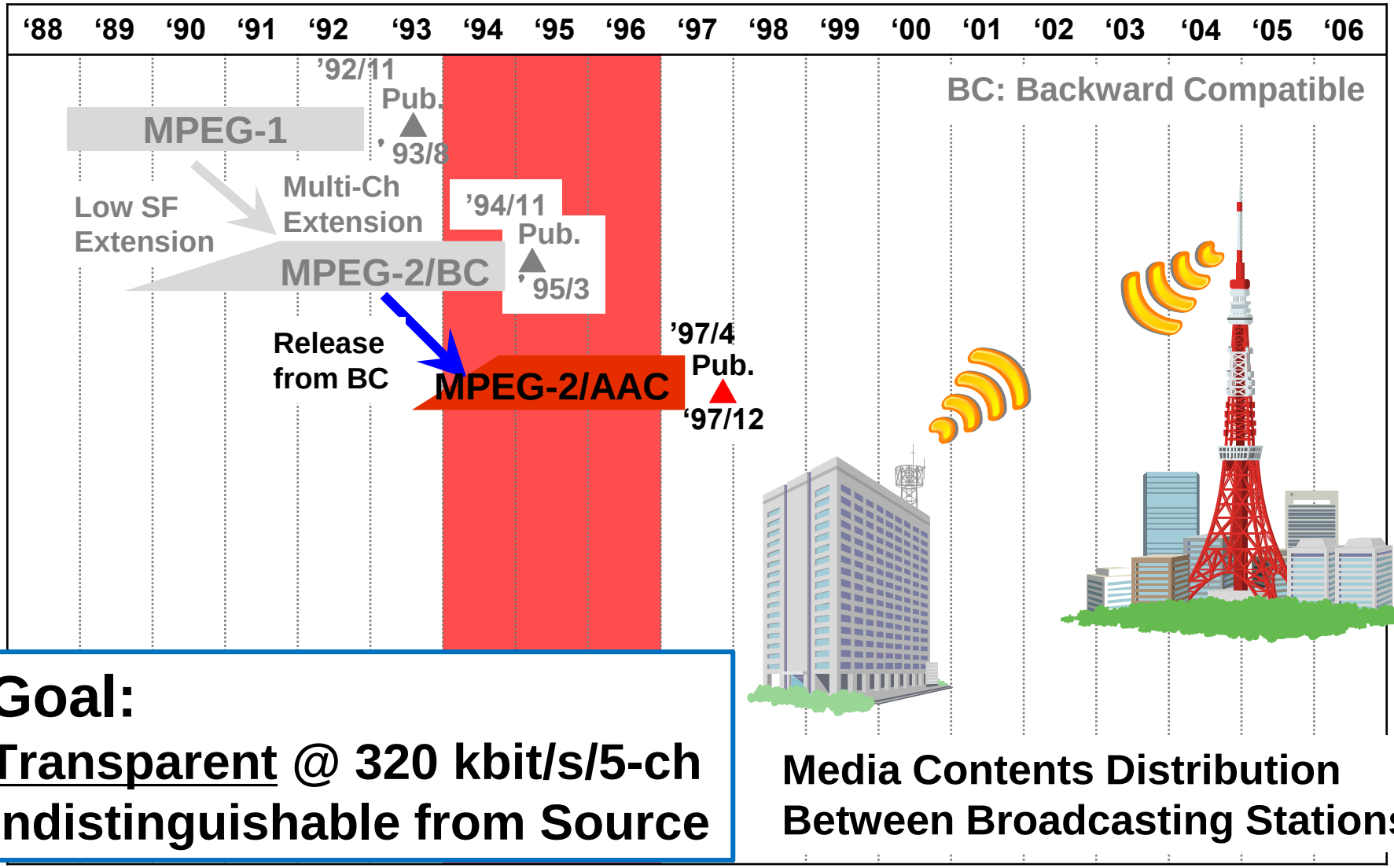
DAT

Magnetic Hard Disk

MPEG-2: More Applications



MPEG-2/AAC: Transparent@Mch



Goal:

<u>Transparent</u> @ 320 kbit/s/5-ch
Indistinguishable from Source

Media Contents Distribution Between Broadcasting Stations

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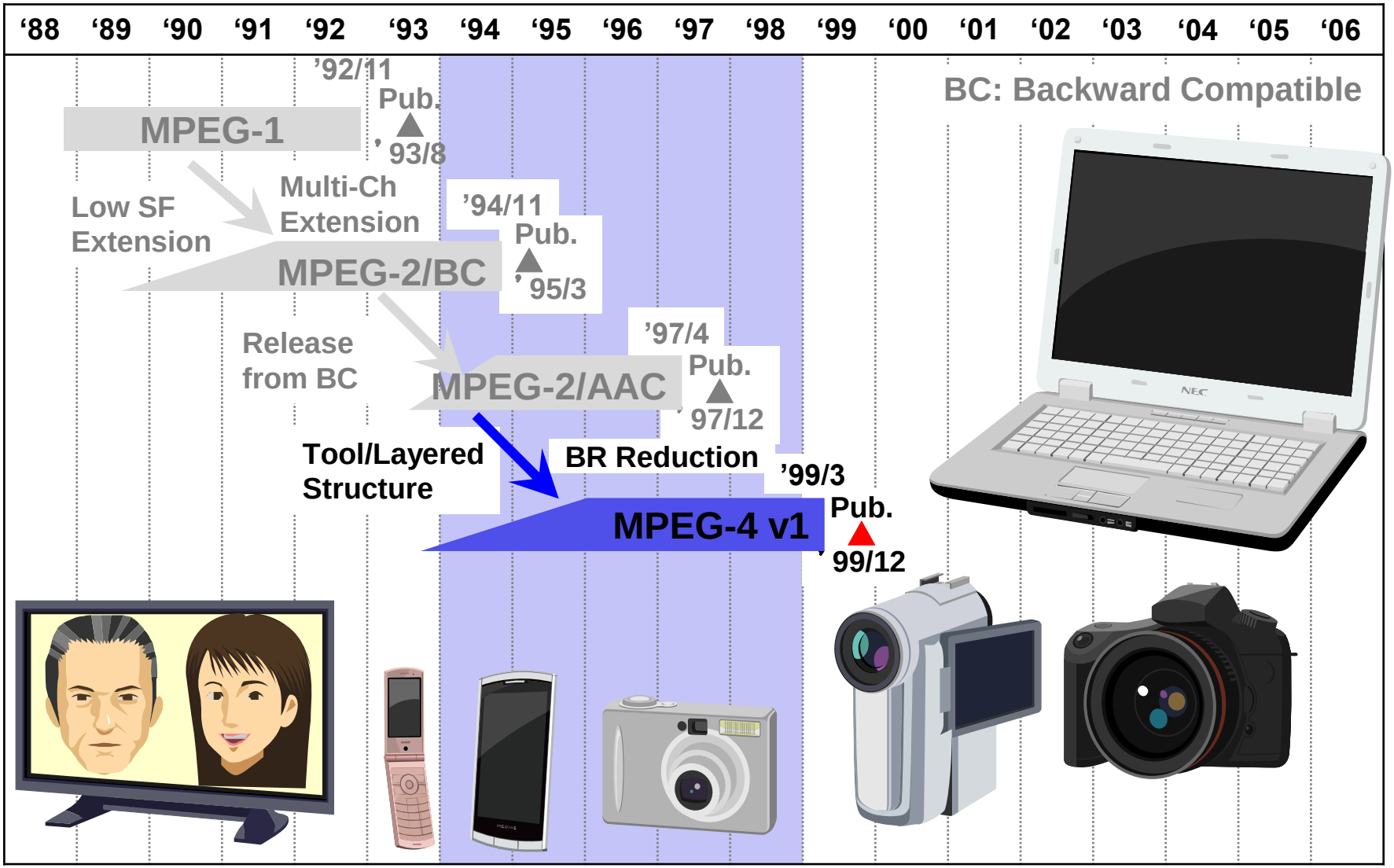
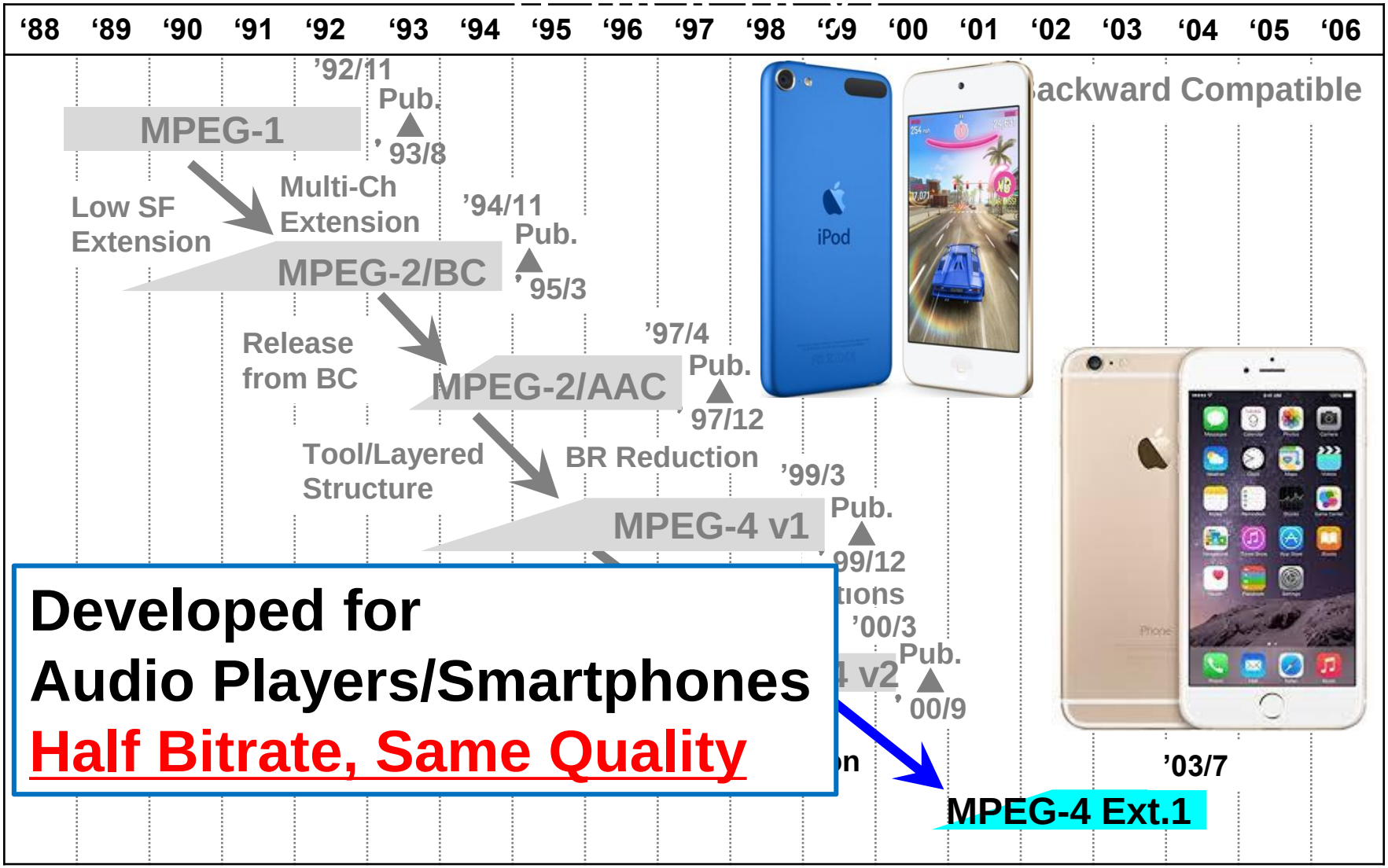
MPEG-4: Versatile Coding for Mobile Apps



MPEG-4 HE-AAC: BW Extension



Birth of MPEG Audio Standards

MPEG-1 Finalists (June 1990)

Best Subj. Score

- ASPEC (AT&T, DTB, FhG, CNET)
- ATAC (Fujitsu, JVC, NEC, Sony)

Best Obj. Score

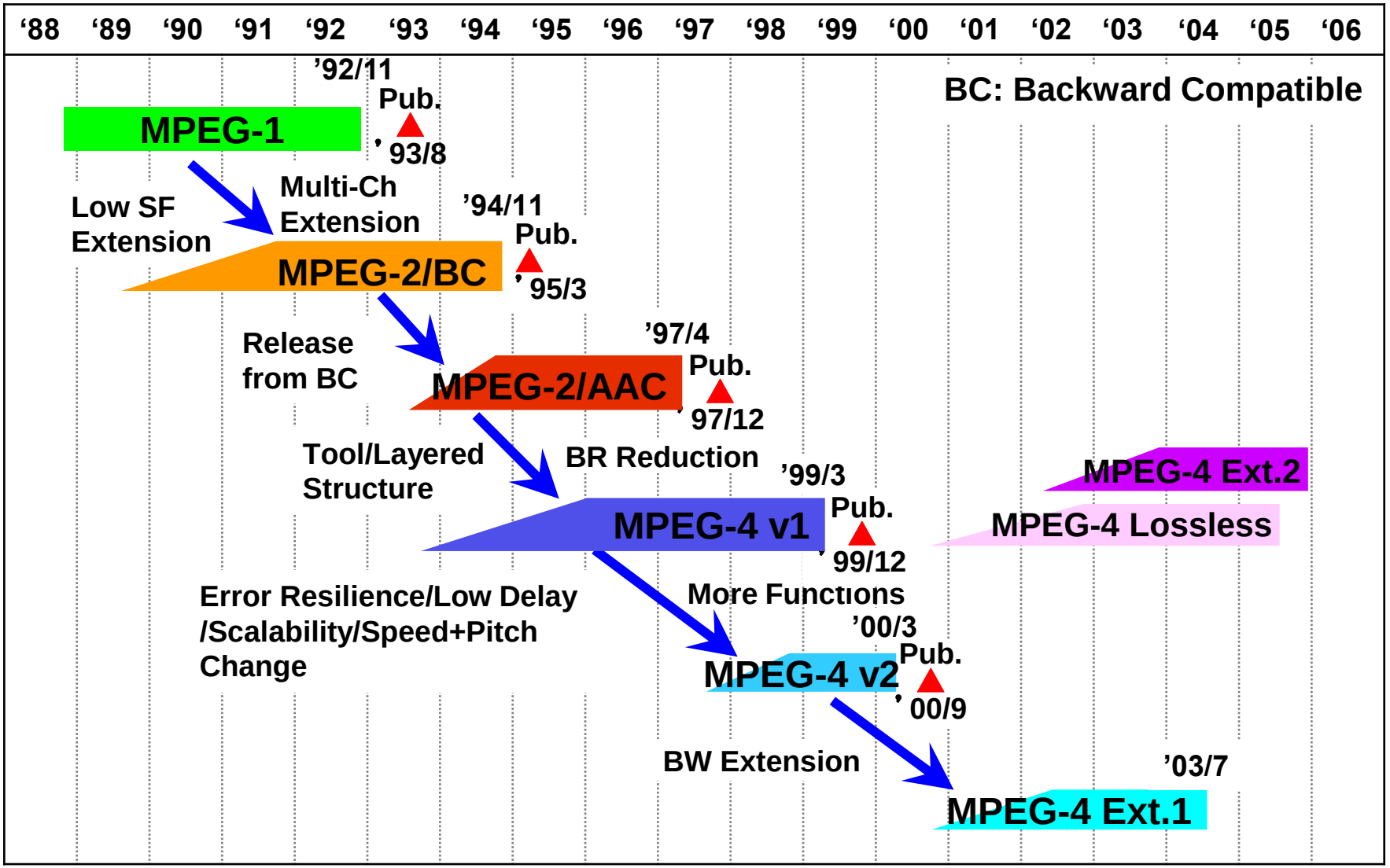
- MUSICAM (IRT, Philips, CCETT, Matsushita)
- SB-ADPCM (NTT, BTRL)

Layer I/Layer II---SB Coding, Psycho.Acoust. Model 1, Intensity Stereo

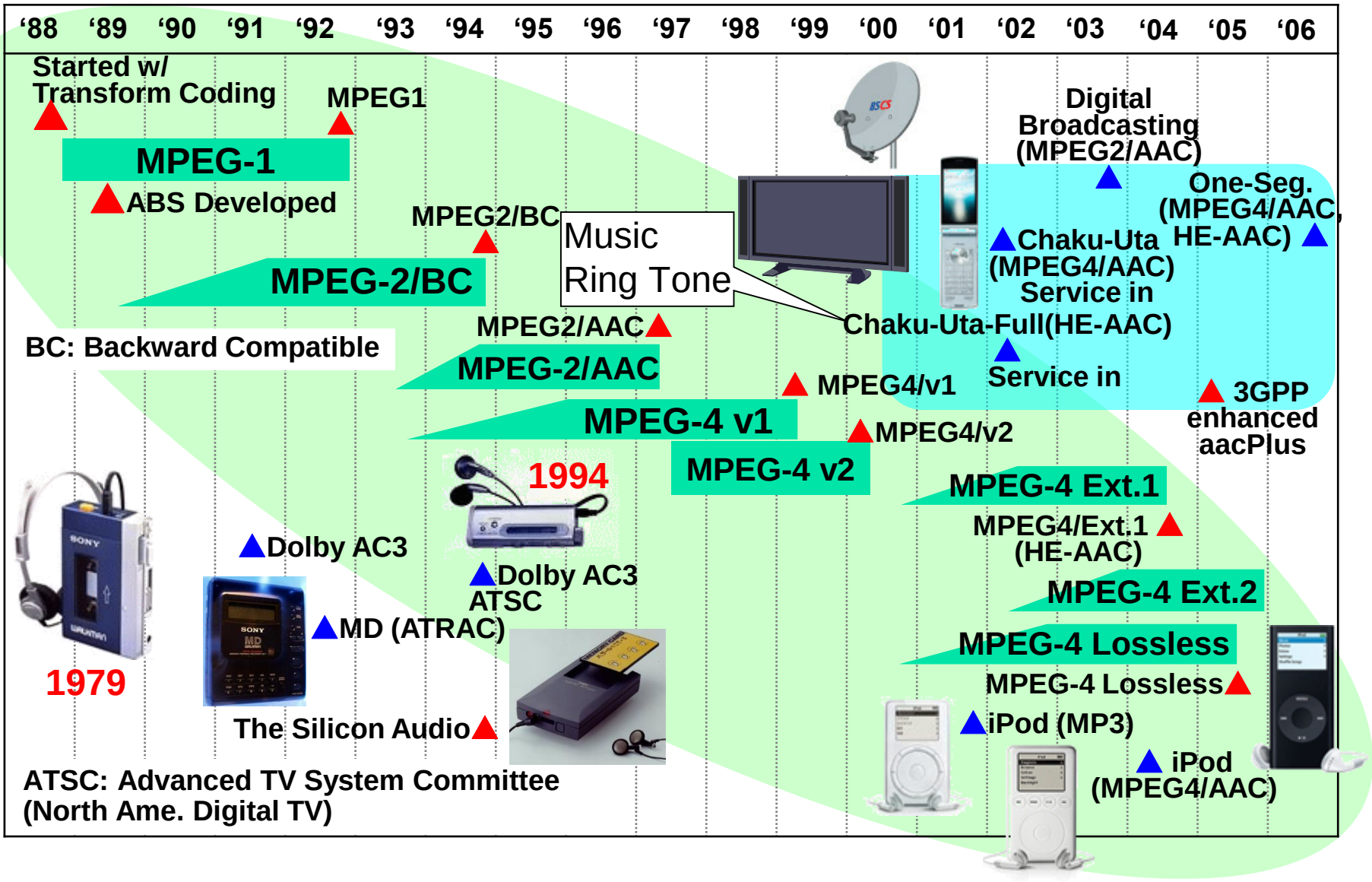
Layer III---Hybrid (SB+Transform) Coding (MDCT+BS), a.k.a MP3 Psycho.Acoust. Model 2, Intensity+MS Stereo

MPEG-2 AAC
MPEG-4 AAC (+LTP)
MPEG-4 HE-AAC (+HQ-SBR/LP-SBR)
MPEG-4 HE-AAC v2 (+Param. Stereo)
MPEG Surround; MPS (AAC+Panning Param.)

Evolution of MPEG Audio Standards



Applications of MPEG Audio



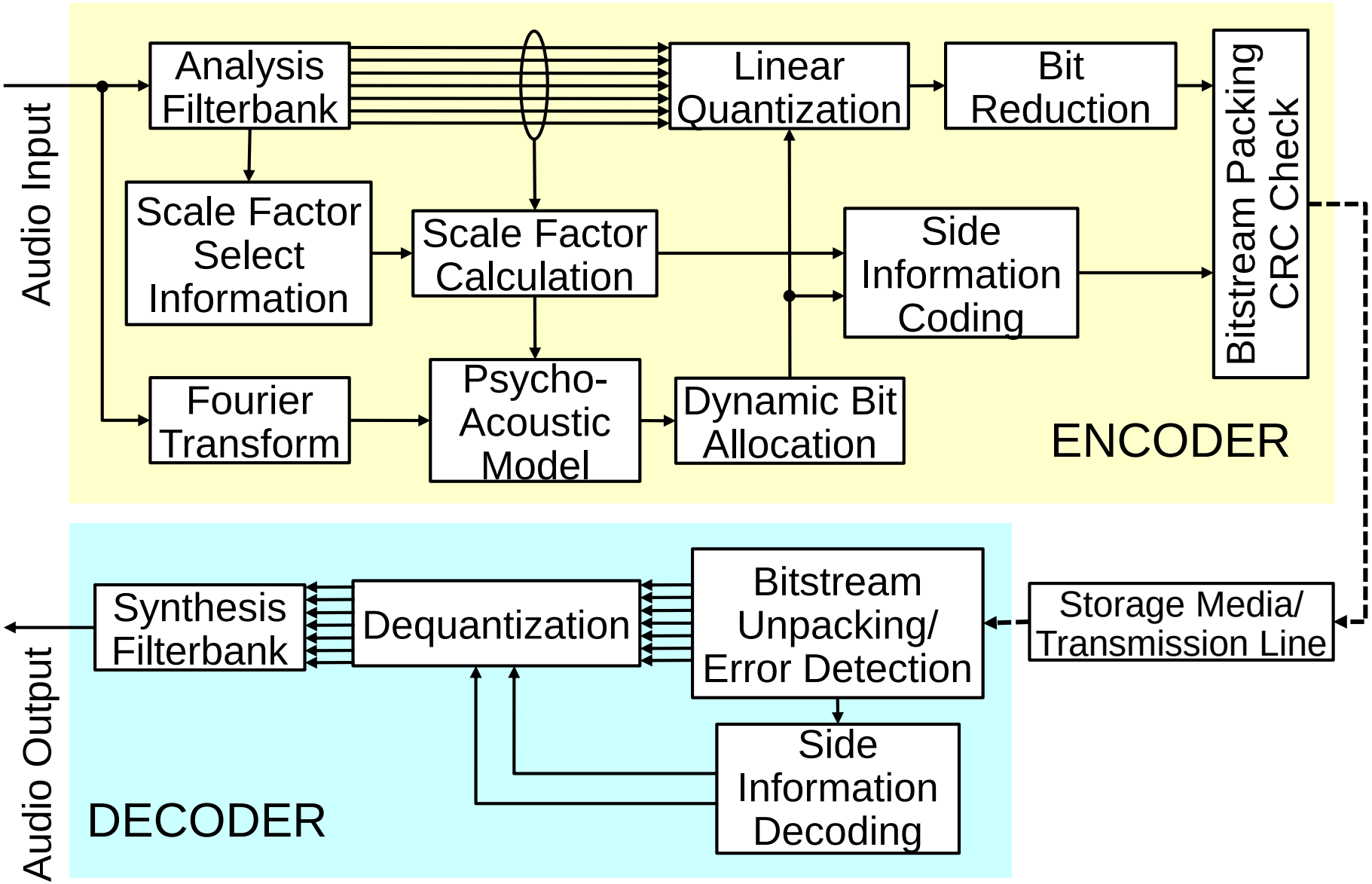
Conventional Audio Players (- 1990)

- Sony: Walkman release (**1979**), personal entertain't
  Analog sig proc/recording, suffer from noise
- CD Players (all-digital, **early 1980s**)
  20 kHz bandwidth + random access.
  Mech mov't causes skips by shakes and vibrations
- DAT in **late 1980s**, lack of random-access capability
  (still magnetic tape as storage)
  Rewind/Fast-fwd to skip contents
- Drawbacks: weight, size, power, reliability

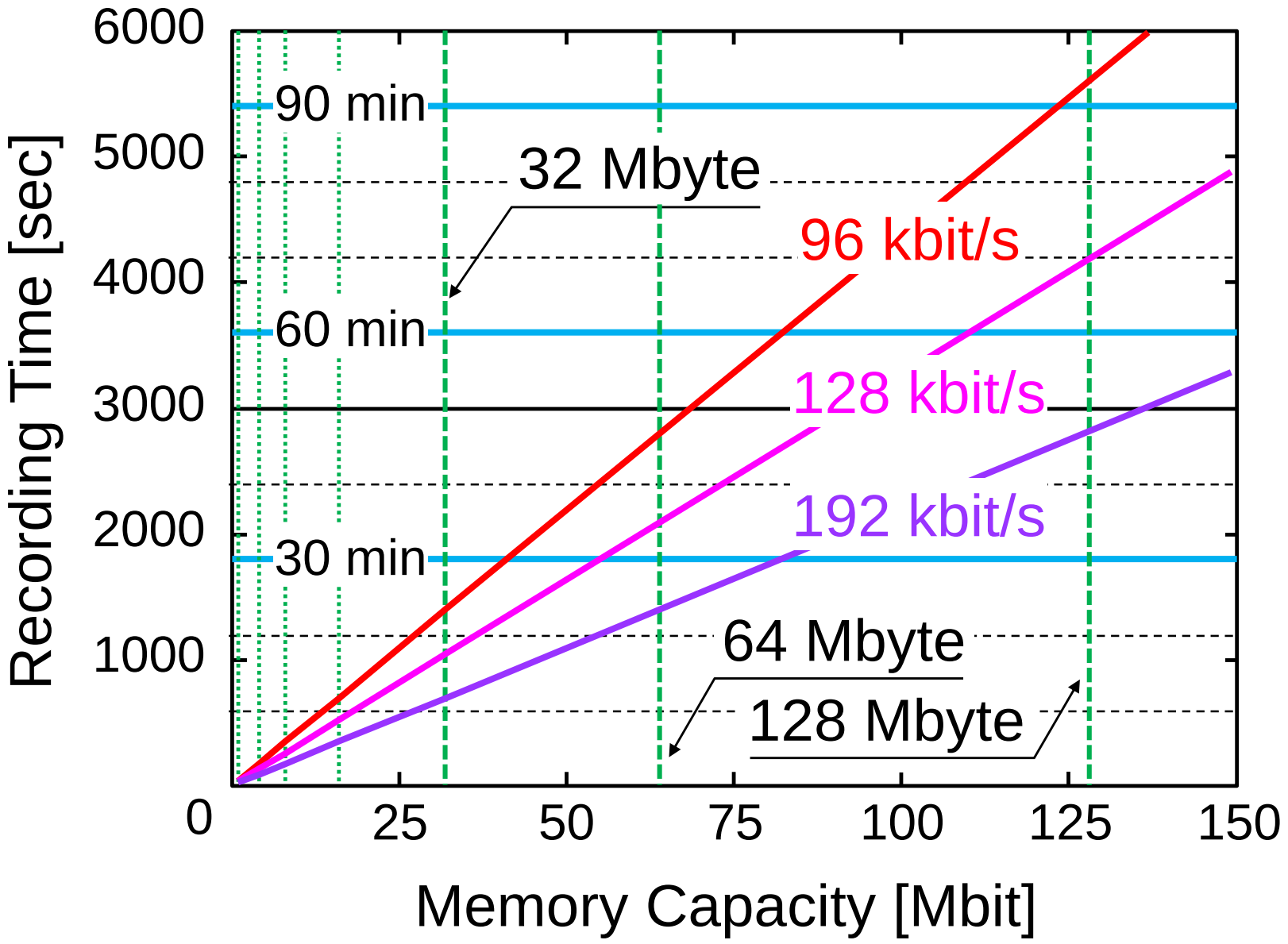
Audio player with semiconductor memory :
potential to solve all these problems.

Silicon Audio

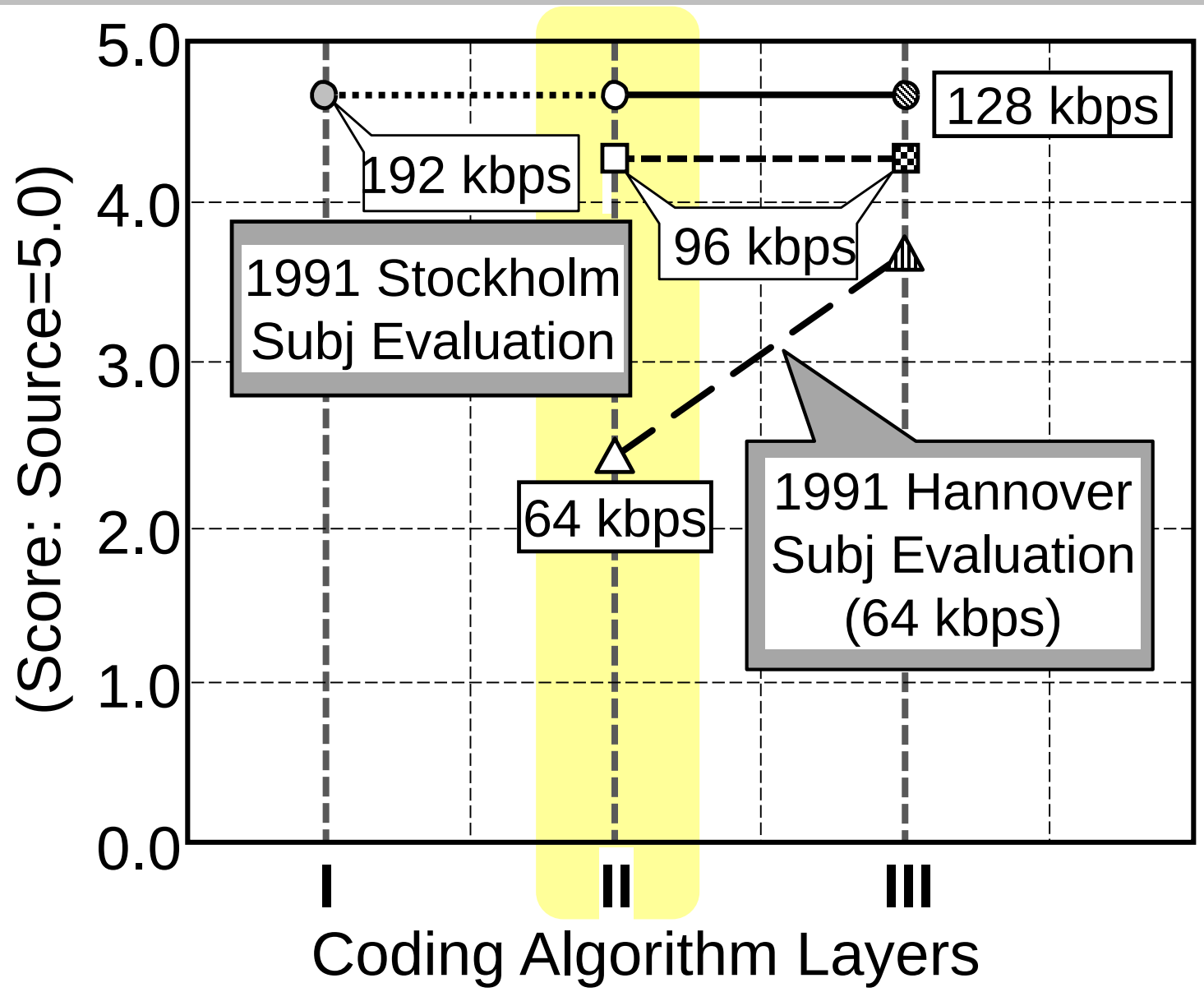
Encoding/Decoding Process, MPEG-1, LII



Memory Capacity vs. Recording Time



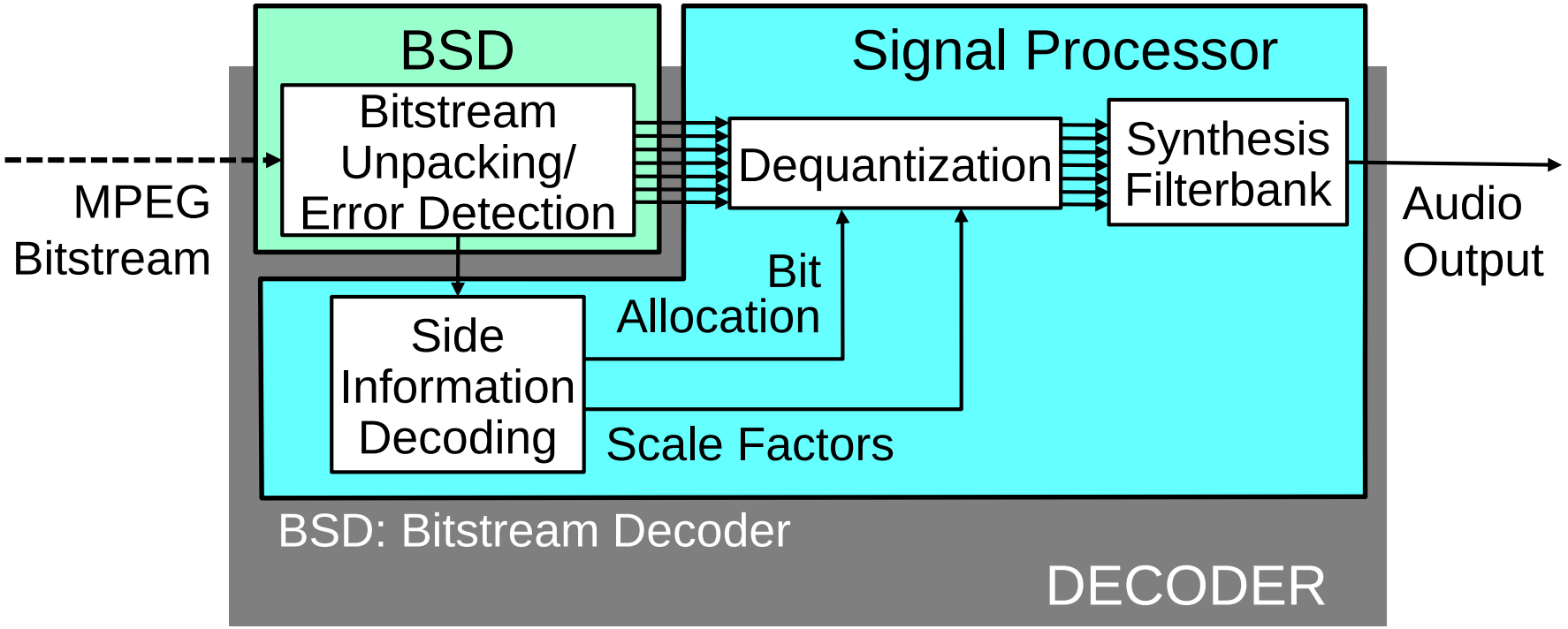
Subjective Evaluat'n Results, MPEG-1 Audio



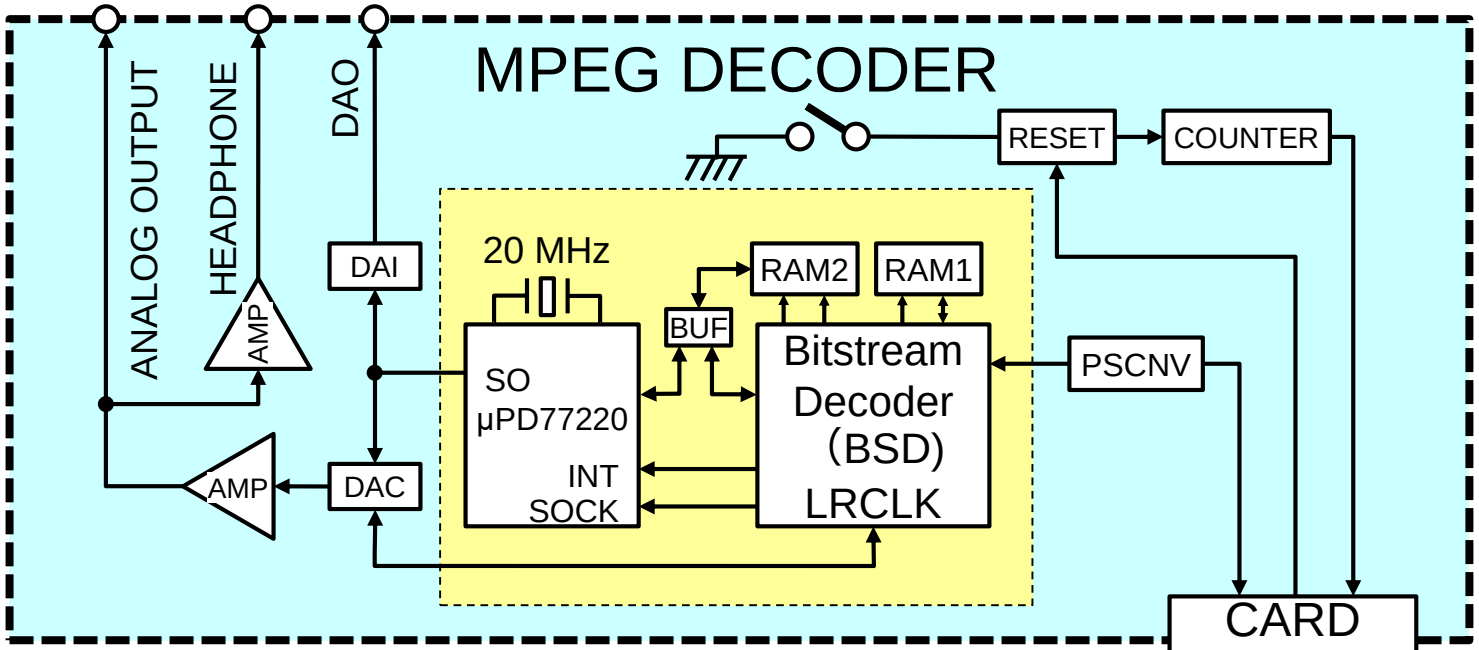
Three Generations of the Silicon Audio

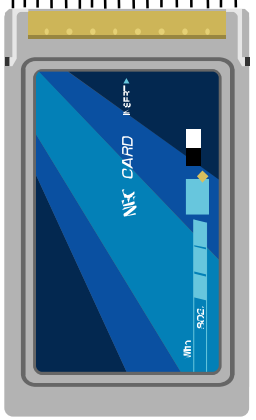
The Silicon Audio and Its Promising Apps

Task Distribution between BSD and Sig Proc



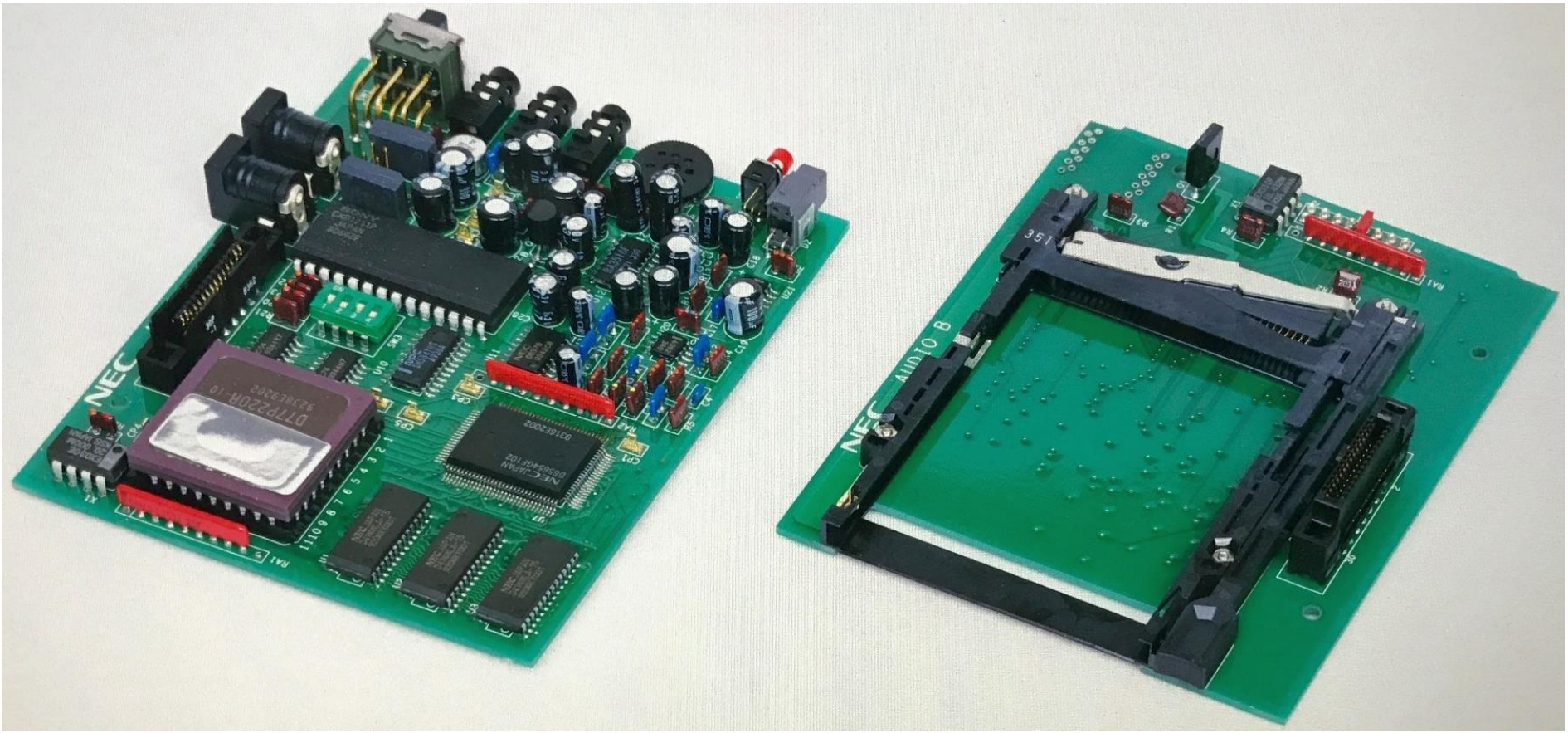
Block Diagram of the Silicon Audio (1st Gen)





AMP: Amplifier BS: Bitstream
DAC: Digital-to-Analog Converter
DAI: Digital Audio Interface
PSCNV: Parallel-to-Serial Converter
DSPSEL: Buffer Control Signal for DSP
RESET: Reset Signal INT: Interrupt Signal
SO: Serial Output BUF: Buffer INTF: Interface
SOCK: Serial-Output Clock
LRCLK: Clock Signal for L/R Switching

PCB of the Silicon Audio Decoder, 1st Gen



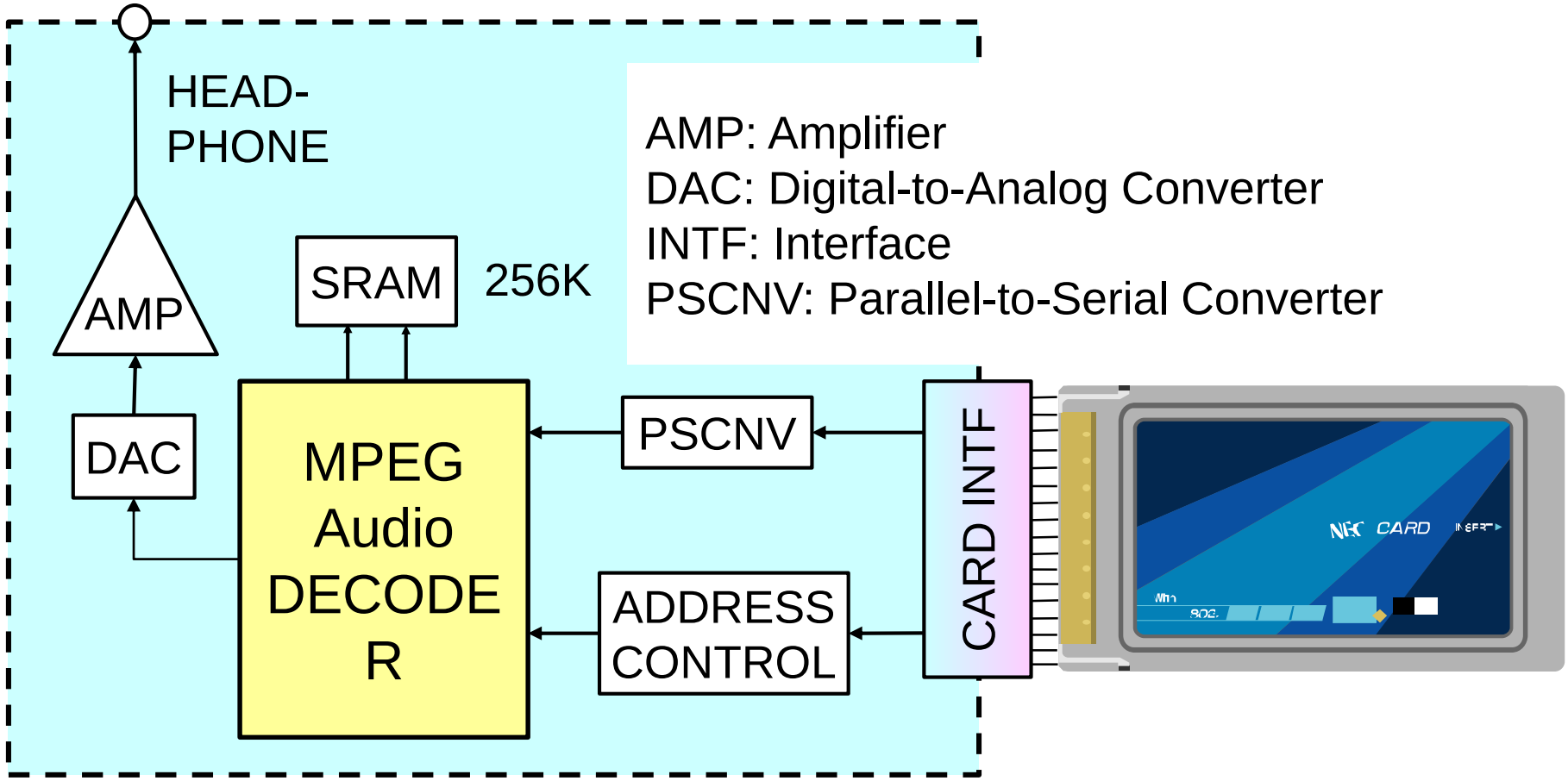
Top View

Bottom View

Specifications of Silicon Audio Player, 1G

Algorithm	MPEG/Audio Layer II
Bitrate	96 kbps/ch
Realization	1 DSP+G/A, 24-bit FixPt
Dimension	127 x 98 x 33 mm
Recording Time	12 min/16 Mbyte

Block Diagram of the Silicon Audio (2nd Gen)



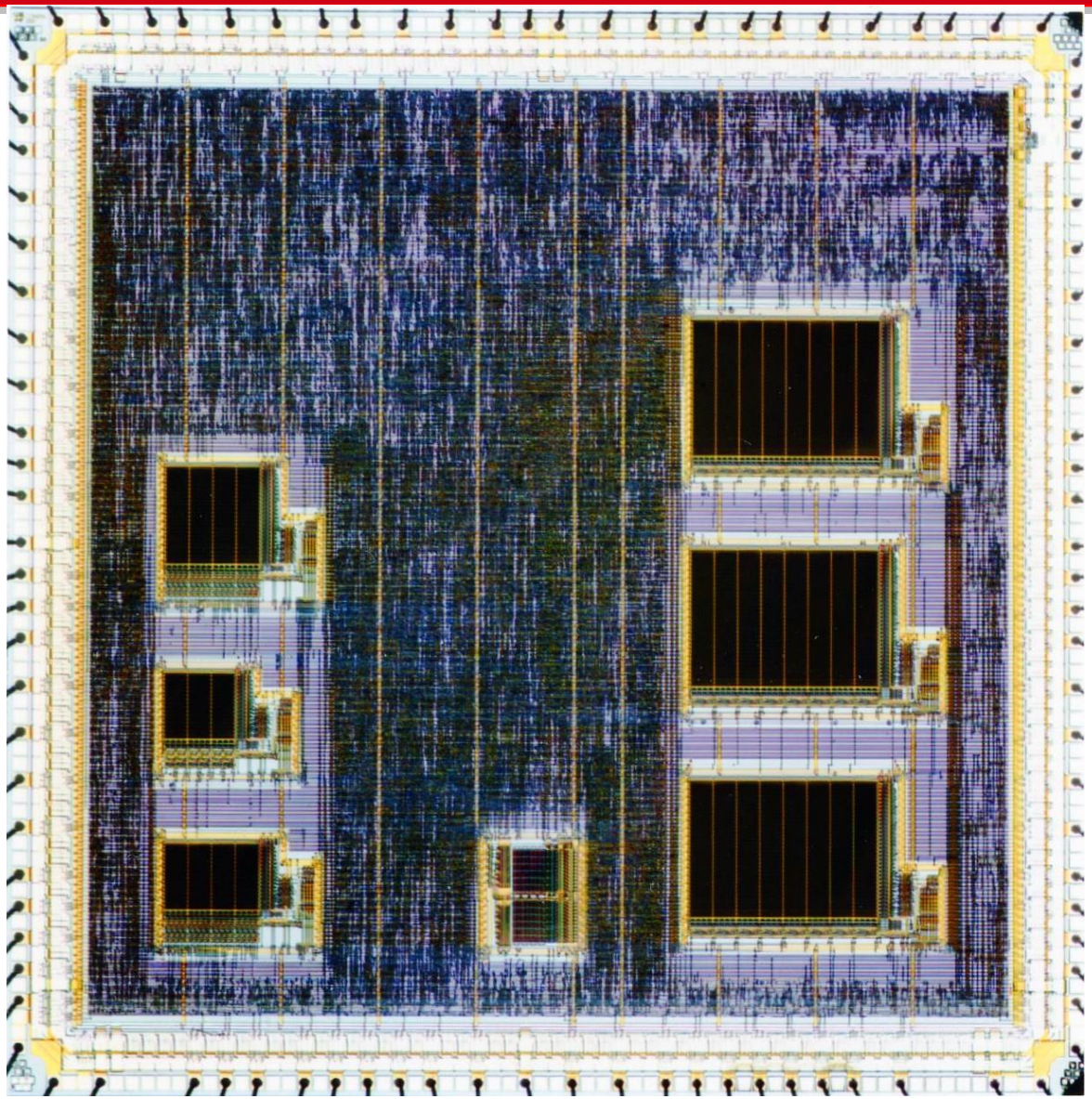
Specifications of Silicon Audio Player, 2G

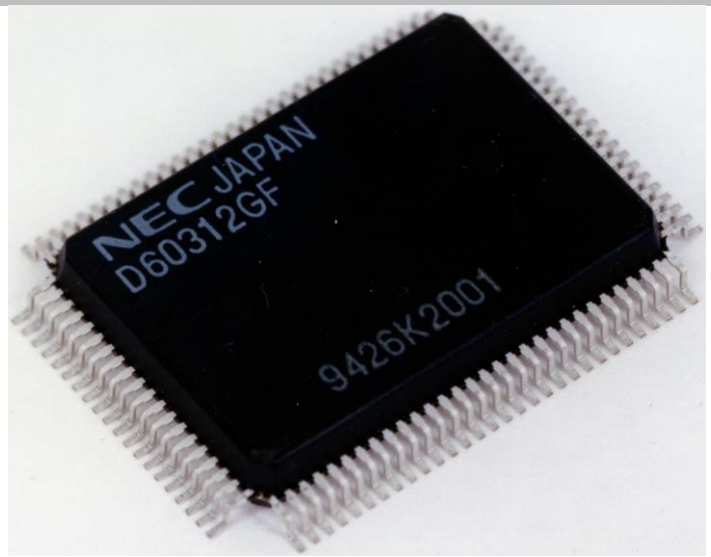
Algorithm	MPEG/Audio Layer I/II
Bitrate	All except free format 96 kbps/ch recommended
Realization	uPD60312+Peripherals
Dimension	131 x 78 x 22 mm
Recording Time	24 min/32 Mbyte

Features of the Decoder LSI

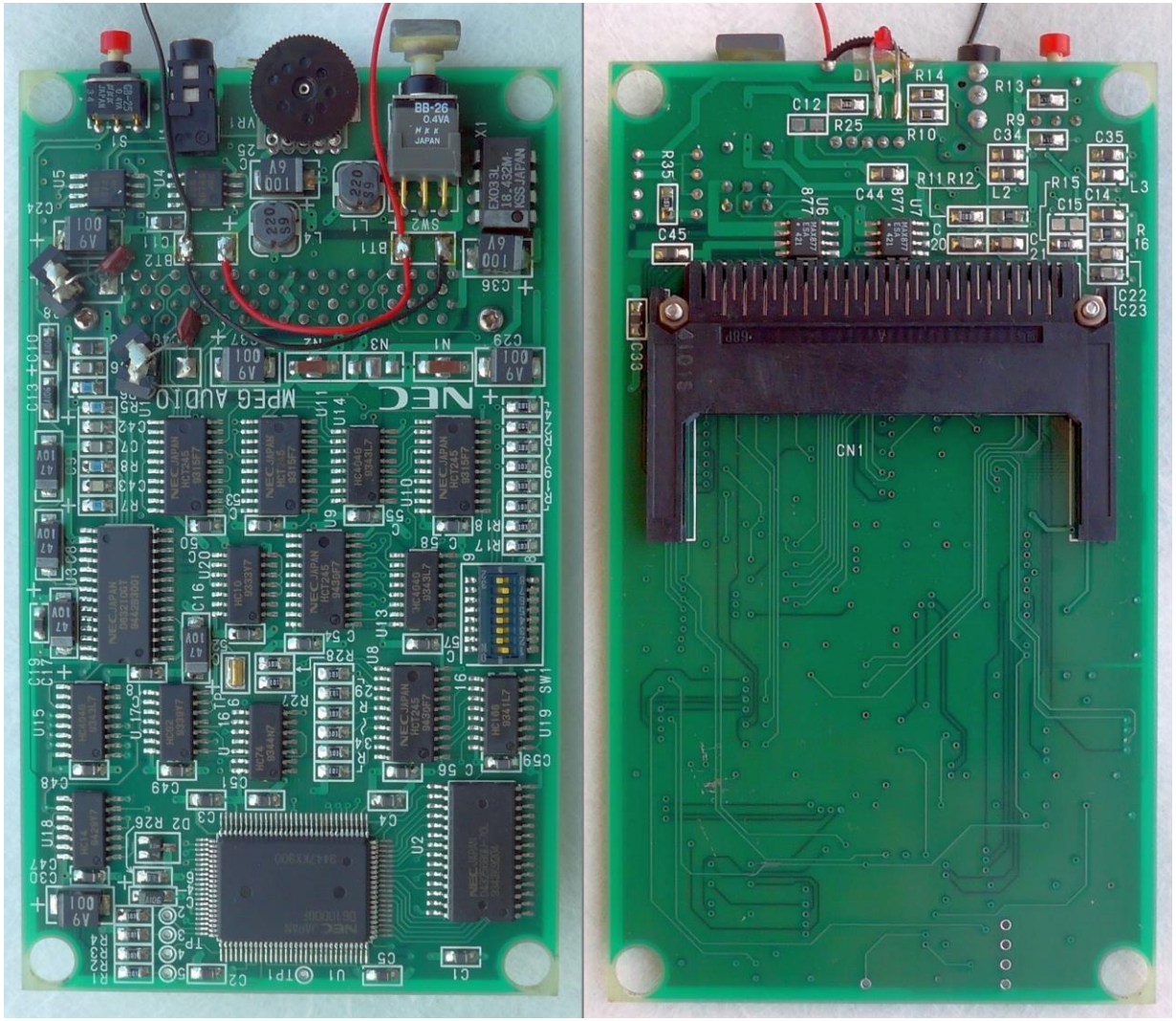
Algorithm	MPEG-1/Audio Layer I/II MPEG-2/Audio LSF Layer /II
Bitrate	All bitrate except free format
Sampling Frequency	16, 22.05, 24, 32, 44.1, 48 kHz
Mode	Stereo, Dual-Ch, Joint St, Mono
Input Bitstream	Serial/Parallel Selective
Max Operating Freq	24.576 MHz
Package	100-pin QFP
Power Supply	5 V
Power Consumption	350 mW

Photomicrograph of Decoder Chip μPD60312





PCB of the Silicon Audio Decoder, 2nd Gen



Top View Bottom View

Challenges Toward Successful Product

1. Memory price: $30@1Mb EEPROM, $0.625@ROM

   Continuous price decline + MP3

   Saehan Information Systems, Diamond Multimedia, DigitalCast (Rio), ReignCom (iRiver), Creative (late 1990s), Sony, Aiwa, Toshiba, Matsushita (Panasonic), Sanyo followed

2. Copyright protection

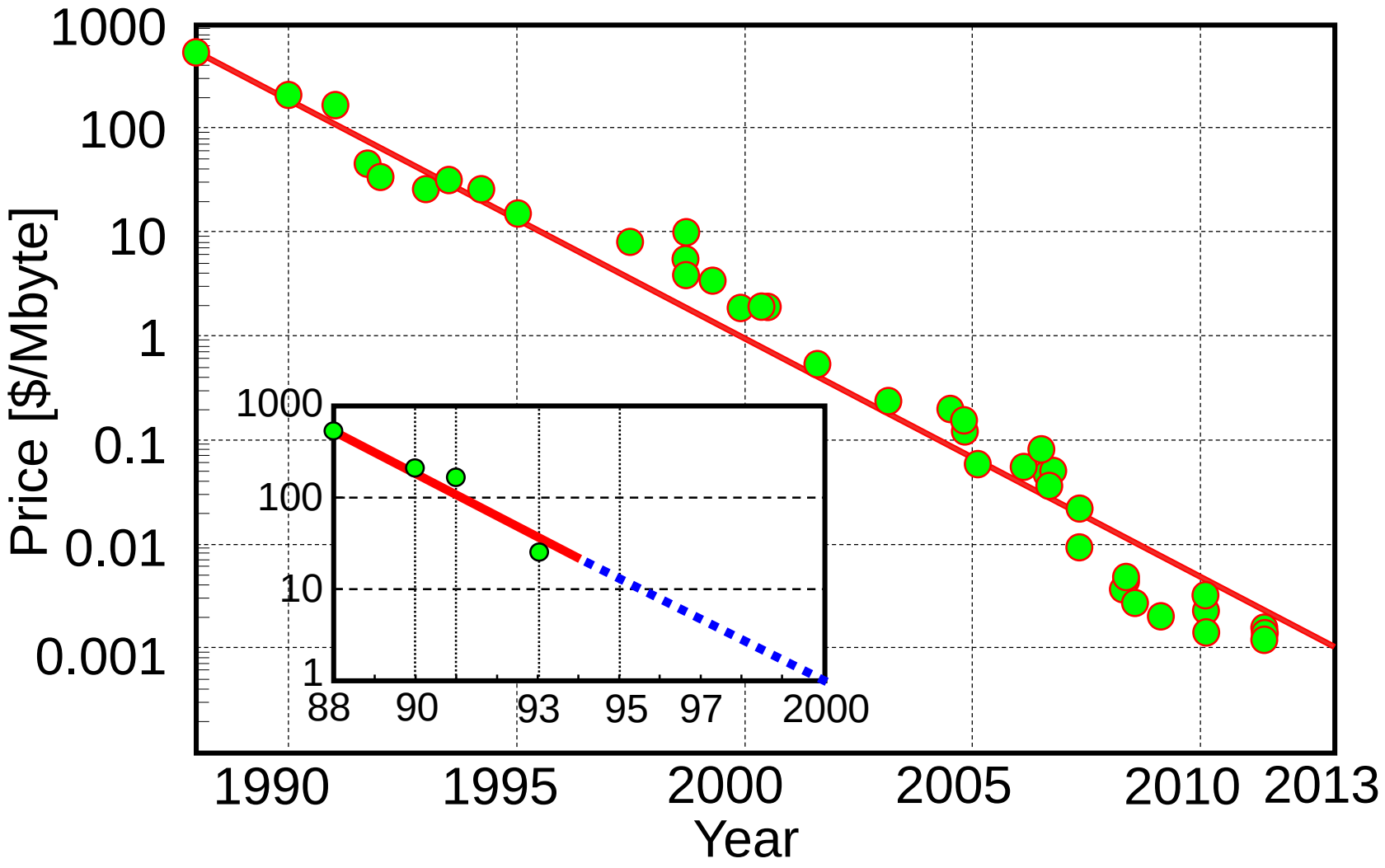
   Hard to negotiate w/ many providers on common DRM

   In-house competition (Sony, JVC)

   Apple tried one-on-one, first to succeed, one-stop shopping (iTunes Music Store)

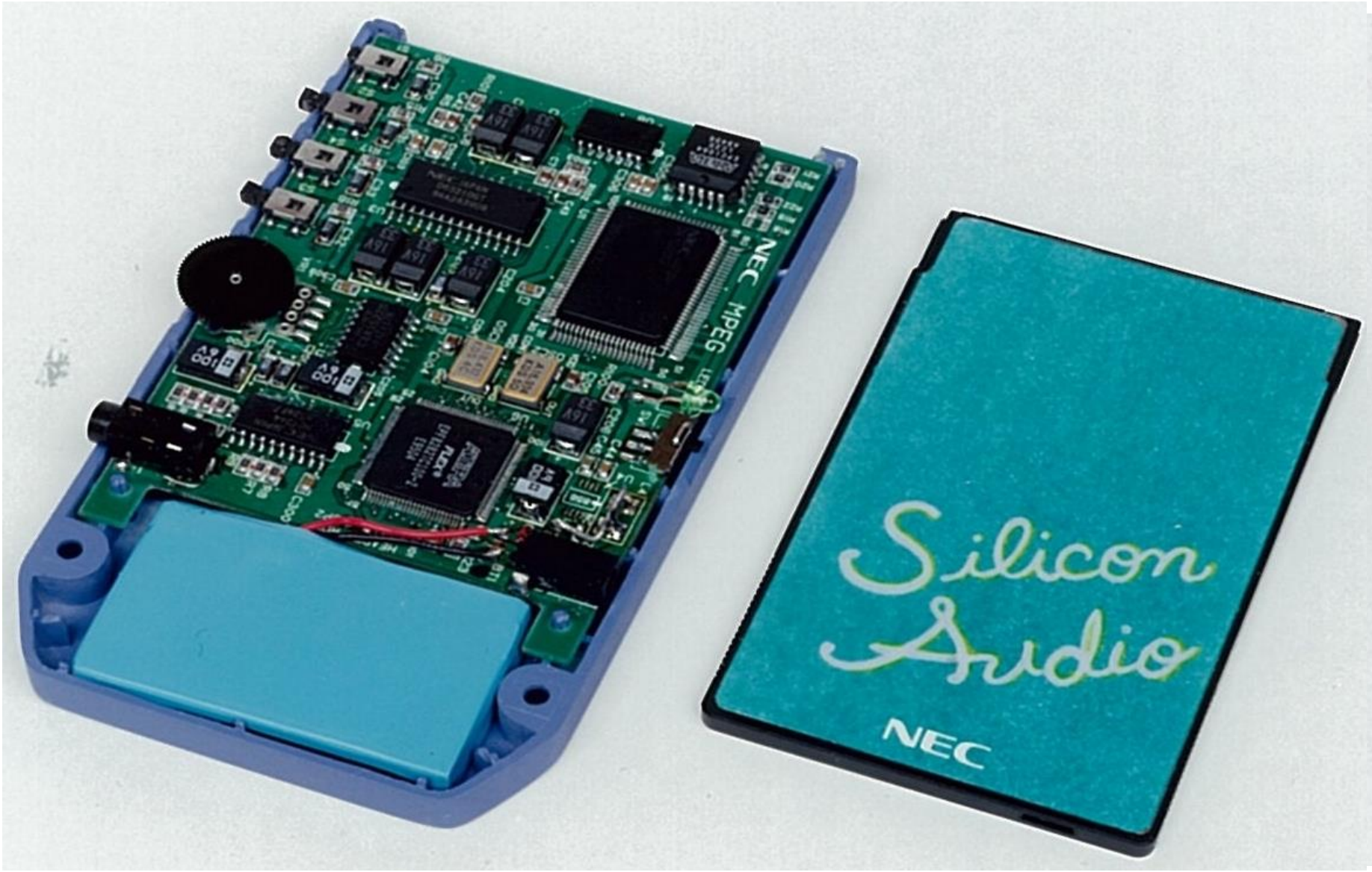
3. Contents distribution

Memory Price in 1990s and 2000s



July 17th, 1995 Issue of Time

Silicon Audio, the 3rd Generation



Silicon Audio: A See-Through Model

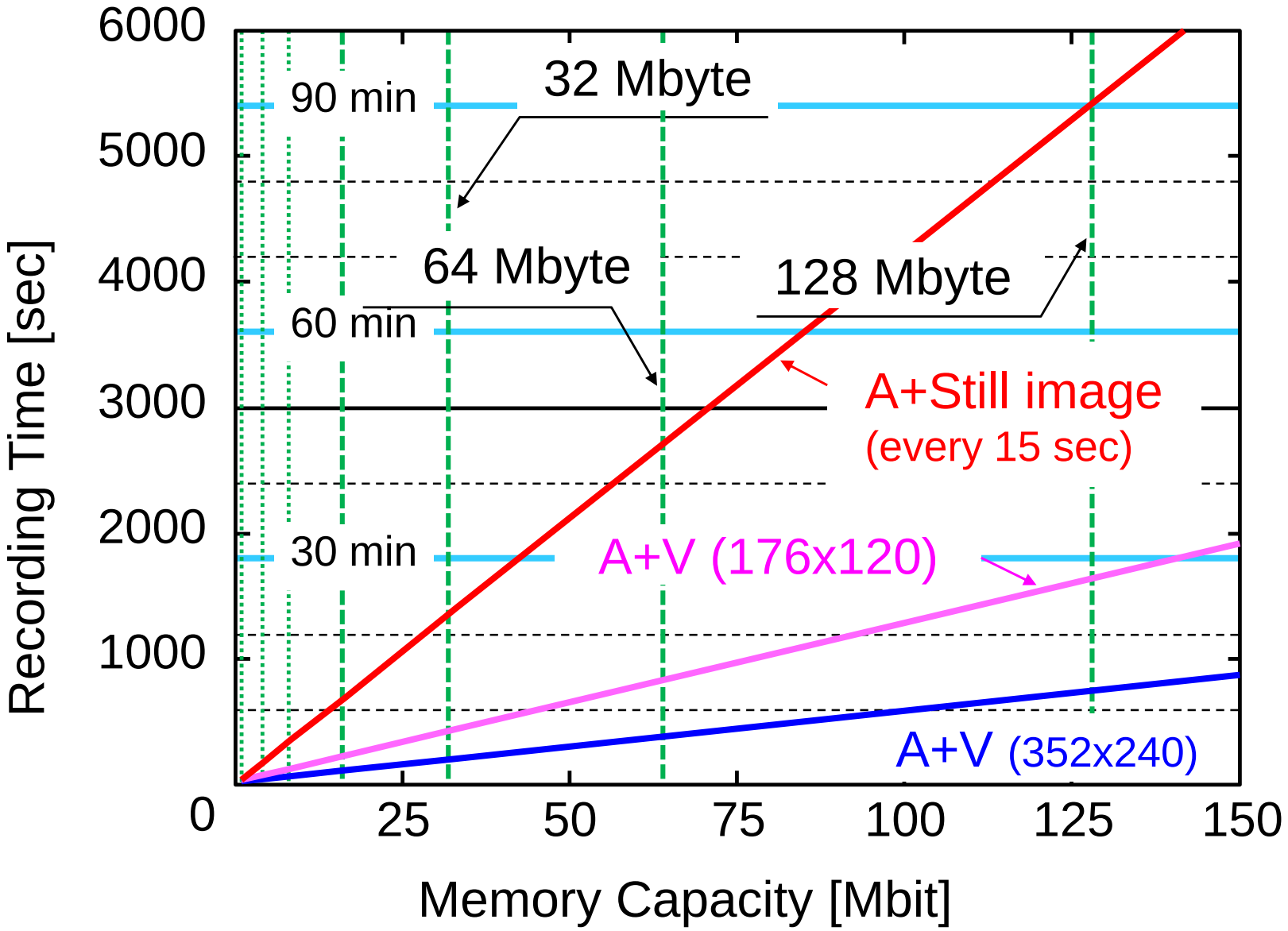
AudioKey MP3 Player by Packard Bell, 2005

Released in 2003

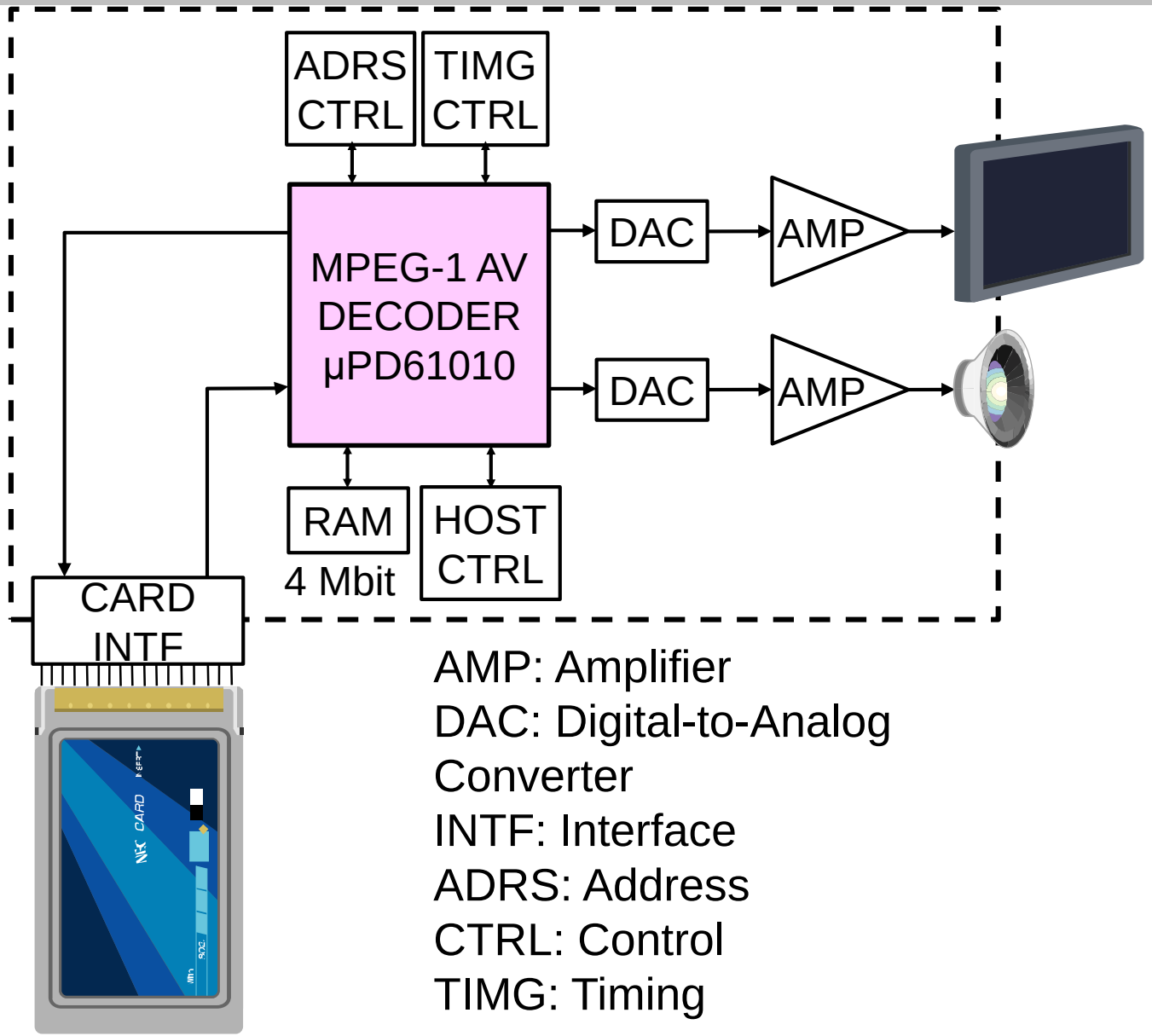
Extension to Video: Silicon View

Model	Portable	Hand-Held
Algorithm	MPEG-1 Video	ditto
Pixels	352 x 240	ditto
Implementation	uPD61010	ditto
LCD	5.5 in TFT	2 in TN
LCD Resolution	320 x 240	312 x 230
Power Consump	5V, 800 mA	5V, 600 mA
Power Supply	External Adapt	3.6 V Lithium Ion, 1300mA
Dimension	222x125x62 mm	147x76x37 mm
Weight	1000 g	295 g
Record Time	4 min@40Mb	ditto

Memory Capacity vs. Recording Time (Video)



Blockdiagram of Silicon View



AMP: Amplifier
DAC: Digital-to-Analog Converter
INTF: Interface
ADRS: Address
CTRL: Control
TIMG: Timing

Silicon View Family (1996)

Portable Model

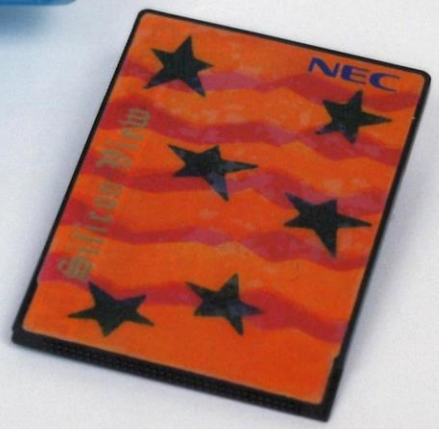
Hand-Held Model

AV Decoder LSI Specifications μPD61010

Video Decoding	352 x 240@30 Hz
	352 x 288@25 Hz
	high-resolution still image
	704 x 480 or 704 x 576 pixels
Audio Decoding	Stereo at 32, 44, or 48 kHz sampling
Max Operating Freq	27 MHz
Package	160-pin PQFP
Power Supply	5 V
Power Consumption	1.7 W

Applications: Silicon Guide Terminals (1997)

Hand-Held AV Model



Audio-Only Model

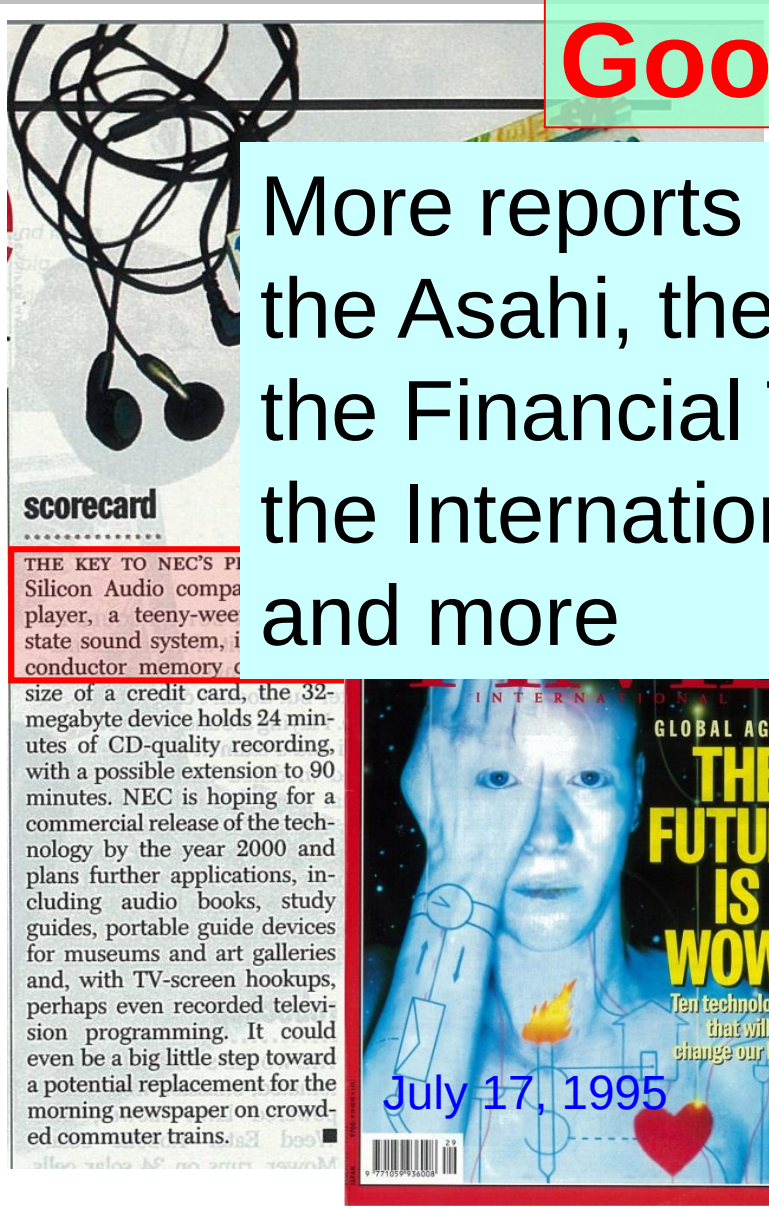
Shopping Navigation (1996)

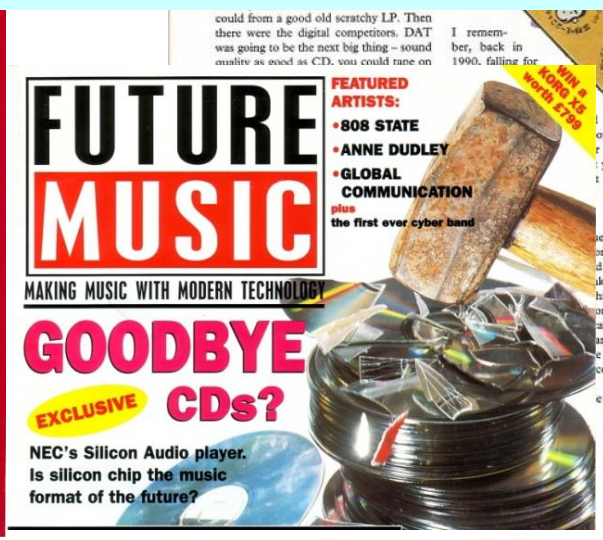
- Main program *A*, *B*, and *C*
- Press a button for a program to start

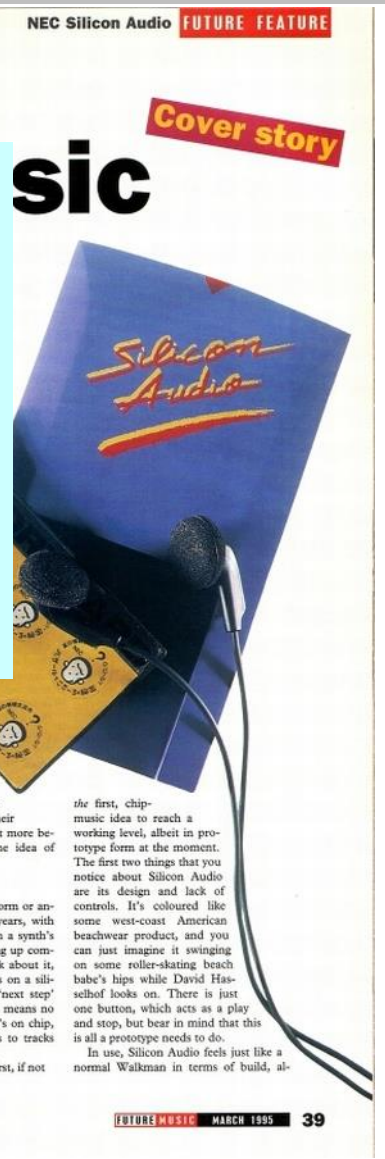
Impact of the Silicon Audio on Feasibility

Goodbye CDs?

More reports in JP, US, UK
the Asahi, the Nikkei
the Financial Times
the International Herald Tribune
and more







Silicon View and its Family

Silicon View (1996)

Silicon Gide (1997)

Shopping Navigation (1996)

Full Page Ad on the Nikkei

Ver.2.0 (1997)

First in the world
No tape, no motor
The future portable video

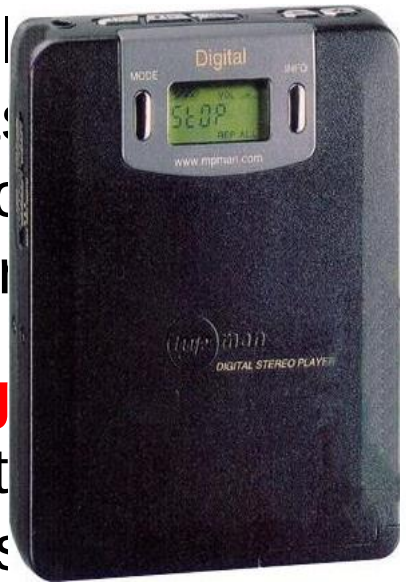
世界初です。
テープもモーターも使わない未来の携帯ビデオ。

Impact of the Silicon Audio on Production

Decoder (+ Encoder later) = Peripherals + LSI (purchase)

Less parts: Earl
Assembly: Parts
No integral proc
assembly exper

Manufacturing
Anybody can st
New companies

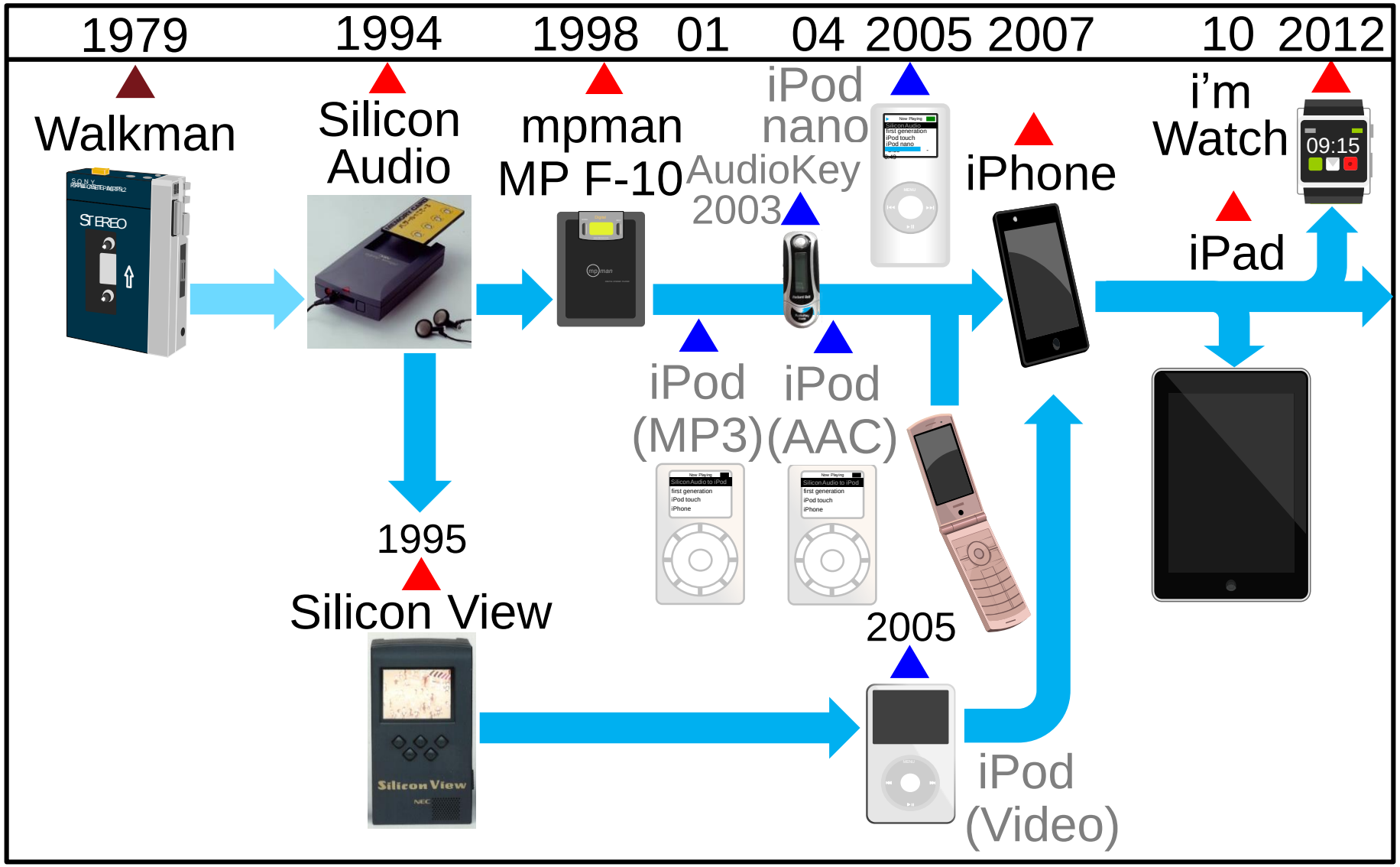


Fossil fuels (gas /diesel) vs. Batteries

Impact of SA on Personal Information Devices

- mpman (1998) : 1st Commercial Solid-State Audio Player
- iPod (2001): MP3+HDD
- iPod (2004): MPEG4/AAC + HDD
- iPod nano (2005): MPEG4 + Flash Memory
- iPhone (2007):
  Aud Player+Mob Phone+PC+UI = Smartphone
  Smartphone : Commodity, Most promising
- Tablet PC (iPad, 2010):
  Upscale iPhone w/ Large Display
  Compromise between Smartphone & PC
- Smart Watch (i'm Watch 2012):
  iPhone – Display – Keyboard

From The Silicon Audio to a Smart Watch



Summary

- The Silicon Audio: Origin of personal information devices,
- Developed in 1994 (25 yrs!) upon encounter of compression ratio and memory capacity
- Matured LSI technology for codec on a single chip

  → Essential to the Silicon Audio family
- Robust against vibrations, suitable for personal carriage and in-vehicle use
- Precursor of mpman (1998) and iPod (2001)
- Changed manufacturing process and players therein
- Evolved into iPod, smartphones, tablet PCs, and smart watches
- Widespread applications i.a.t. players, such as video players and shopping guide on the shelf

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