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Description

This report presents the empirical study of standardisation of audio-visual CODECs in the EU and China, including a preliminary analysis of the factors shaping the emergence of these standards.

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1. Introduction to the report

1.1. Guide to the document

This document is Deliverable 12 (D12) – "Final report on Standards Dynamics – Audio-Visual". It is a report presenting "a mapping of the standardisation settings, a review of the current standardisation process, an examination of the strategies of different players within the standard setting processes, an examination of the attitudes of industrial players towards standards adoption and an analysis of possible standardisation and innovation trajectories and outcomes.".[1]

This report should be seen as a follow-up to the already presented D3 "Review of state of art – EU & China" and D9 "Interim Report on Standards Dynamics – Audio-Visual", and provides background for and key developments in the domain of audio-visual CODEC standards in China for the subsequent analysis to be undertaken in Deliverable 16 "D16: Report analysing implications for China and European policies."

1.2. Empirical background

Empirical investigation undertaken in the work package contributing to this report was aimed as synthesizing and ordering scarce empirical materials on the case, and coping with the challenge of having often controversial or disparate views on the standards development dynamics.

Field studies were conducted by Junbin SU (a member of the Tsinghua University consortium, now working in the School of Journalism and Communication, Xiamen University), and Vladislav FOMIN of Vytautas Magnus University during his visit to China to attend the project's meeting at Tsinghua University in Beijing.

1.3. Acknowledgements

This work would not be possible without the assistance of fellow researchers from the China-EU project, the staff of the faculty of Informatics of the Vytautas Magnus University, as well as anonymous interviewees from China who kindly shared their knowledge with the author.

[1] As defined in the Technical Annex, Section.

2. Introduction to the case: standards dynamics – Audio-visual

> *"The issue of EU-China dialogue [on standardisation] cannot be seen as simply a case of the EU having experience and learning of 'best practice' to offer China, but needs to be seen as the EU and China as equals confronted with a similar set of domestic and international issues, and with a mutual interest to find solutions that are harmonious" (Ure, 2006, p.29).*

2.1. The case of AVS

CODEC is abbreviation of COder/DECoder pair, which can be processor in hardware or algorithm in software capable of encoding/decoding, compressing/decompressing a digital signal (Wikipedia.org, 2008).

AVS is a global standard of audio-visual CODEC that emerged from China as a competing standard to already globally established and widely used MPEG2 standard. While the most often quoted reason for starting the work on the new AVS standard is that of opposing the IPR/ patent fees structure of the MPEG standard, this report aims at presenting a richer picture of the AVS standardisation dynamics. This dynamics, however, is better understood when a background on the dominant international CODEC is presented.

2.1.1. The dominant international audio-visual CODECs

There are two audio-video (de)coding standard series developed internationally, by joint efforts of ISO/IEC Joint Technical committee 1 (JTC1) – MPEG series standard, and ITU – H.26x series audio-video (de)coding standard. The ITU-T H.264 standard and the ISO/IEC MPEG4 Part 10 standard (formally, ISO/IEC 14496-10) are jointly maintained so that they have identical technical content. In developing and maintaining MPEG4/H.264, the ITU-T's, Video Coding Experts Group (VCEG) collaborates with the Moving Picture Experts Group (MPEG) of the ISO/IEC in a partnership effort known as the Joint Video Team (JVT). The effort builds on the previous successful development of the MPEG2 standard, which was implemented under MPEG and ITU cooperation in 1994 and since has seen very broad international acceptance, through, e.g., the use in DVD discs/players, digital TV broadcasting systems and appliances, etc.

H.264 is an extremely scalable CODEC. From 3G to HD and beyond, H.264 provides excellent quality to the broadest range of bandwidths and user scenarios. Best of all, H.264 is a standard — so companies across the telecommunications, consumer electronics and broadcast industries can create products that will interoperate with one another (Apple.com 2008). H.264 has been broadly adopted by organizations representing everything from mobile phones to HDTV, and you will find a broad spectrum of interoperating products — consumer and professional, hardware and software — supporting this standard (Apple.com 2008).

H.264 has been ratified as mandatory in both the HD-DVD and Blu-ray specifications for High Definition DVD (Wikipedia.org 2008).

In terms of broadcast, H.264 has already been adopted by Europe's DVB, the top 6 Japanese broadcasters, and is under final consideration in the US's ATSC. The ITU-T has chosen H.264 for its H.241 videoconferencing specification. MPEG4/H.264 is integrated in three mobile TV standards: The South Korean T-DMB, the European DVB-H, the Qualcomm's MediaFLO. And in the mobile arena, H.264 has been adopted by the 3GPP (for GSM) organization and is under final consideration with the 3GPP2 (for CDMA2000) organization (Wikipedia.org 2008, Mediaflo.com 2008).

In the Internet domain, major software manufacturers adopted MPEG4/H.264 in their widely popular products. Adobe's Flash Player 9 – the software for advanced authoring environment for creating rich, interactive content for digital, web, and mobile platforms, interactive websites, rich media advertisements, instructional media, engaging presentations, games, and more – includes MPEG4 Part 12 (container) and Part 14 (H.264) video and High Efficiency AAC (HE-AAC) audio CODEC support. Apple's QuickTime Player also includes support for H.264 and AAC. And so does Microsoft's Media Player.

An important milestone laying a solid ground for the consumer adoption of H.264 video standard took place in October 2005, when computer maker Apple Inc. began selling H.264-encoded videos over the Internet through their revolutionary iTunes Music Store (Wikipedia.org 2008). Initially selling just television series and music videos, they expanded in September 2006 to sell films. Later in 2007, YouTube started to automatically encode all new uploads with H.264 (Wikipedia.org 2008).

In the telecommunications domain, ITU-T has been long developing and maintaining codecs standards for videoconferencing applications and devices, amongst others. H.264/AVC is one of the standards which is widely used for videoconferencing.

To date, H.264/AVC is employed widely in applications ranging from television broadcast to video for mobile devices. In order to ensure compatibility and problem-free adoption of H.264/AVC, many standards bodies have amended or added to video standards so that users of these standards can employ H.264/AVC.

Since H.264 is a freely available standard[2], companies around the world can create products that will interoperate with one another. In addition to the enormous benefits of H.264 being a worldwide standard.

2.2. Some technical aspects of AVS and H.264 codecs

The standardisation work of AVS actually includes nine separate technical parts (for the integration of the system, audio, video, and digital copyright management, requirements and test, reference software, mobile video, AVS for IP, and AVS file format). The focus of this report is AVS standard for video compression, which became a national standard in China in April 2005.

The AVS is an audio-video coding/decoding technique focused on compression/decompression of video images and sound. The essence of differences between the MPEG2/4 and AVS, as will be elaborated in this report, has two dimensions – that of IPR policy and technical performance.

With regard to technical performance, AVS is positioned between MPEG-2 and H.264/MPEG-4 AVC (H.264). The AVS offers data compression rates two or three

[2] See Appendix 1 for patent pool information.

times higher than the MPEG-2 scheme. When compared with the H.264 standard, the AVS features lower computational complexity while producing nearly identical image quality of HDTV images[3].

With regard to IPRs, AVS features lower patent license fees (TTC, 2007, p.32). Opposing MPEG LA[4][5] which presented licensing structure of MPEG2 Visual, in January 2002 development of an alternative standard was proposed by a group of specialists from all over the world who convened in Beijing in March 2002 (Asakawa & Som, 2006, p.286). The resulting standard is not just Chinese standard but is meant to be the global standard, one capable of challenging the existing global patent system (Updegrove, 2007) and promising to play a prominent role in the future all-IP Next Generation Networks (NGN).

2.3. Global and local drivers for AVS work

The rollout of IP multimedia subsystems (IMS) with all-IP infrastructure – the endeavour under the NGN[6] rubrics – would simplify the current silo-based service delivering mechanism by creating a layered service delivery concept that would maximize the reuse of existing resources and minimize the development and implementation time for new services (Tse & Artero, 2007, p.2). Thanks to IMS, the same service architecture is effective whether the end user is using fixed-line or wireless access technology on an Internet-connected computer or mobile phone (Tse & Artero, 2007, p.2). The interoperability of services implied by the IMS ascribes an important, if not vital role, to CODEC standards, such as AVS, as those enable production and delivery of digital (video) content across user sites and devices.

The importance of NGN rubrics and the crucial role of Audio-visual codecs is also unambiguously referred to in The eleventh five-year plan of the development of hi-tech industries of the Chinese National Development and Reform Commission (NRDC, 2006), as quoted below:

> *"Fundamental core industries such as Integrated circuit and software shall be developed and emphasis shall be put on the **cultivation of such emerging industrial** clusters as **next-generation network**, new-generation mobile communication, digital TV and high-performance computer and network equipment, promoting the transfer of electronics and IT industry development from the speed-and-scale-oriented type to the innovation-and-benefit-oriented type" (NRDC, 2006, p.8, emphasis added).*

[3] Specifically, the AVS foregoes the use of coding algorithm, which is adopted by H.264, and reduces the number of reference frames to two, as opposed to up to 16 frames used by H.264.

[4] MPEG LA is an agency, managing patent pools of MPEG2, MPEG4, and H.264. The MPEG LA patent pools consist of some, but not all patents of MPEG2, MPEG4 and H.264.

[5] It is well recognized globally that the cost of the patent pool royalties, such as MPEG LA, has obstructed the diffusion of technological innovation.

[6] "Next Generation Networks Global Standards Initiative (NGN-GSI) focuses on developing the detailed standards necessary for NGN deployment to give service providers the means to offer the wide range of services expected in NGN. NGN-GSI harmonizes, in collaboration with other bodies, different approaches to NGN architecture worldwide." http://www.itu.int/ITU-T/ngn/

> ***"****Giving full play to the function of market mechanism, we shall develop* ***digital products*** *and* ***network-based audio and video entertainment products*** *to promote the strategic transform of audio & video industry from a simulation-technology based industry to* ***digital-technology based industry****. Priority shall be give to the development of the digital TV industry to establish a digital TV industry system ranging from core parts and components to whole-machine product, from hardware to software, from system to terminal, and from manufacture to providing service. We shall promote the development of* ***digital video and audio broadcast*** *and* ***make breakthroughs in such key technologies as digital video and audio encoding and decoding and content protection****. We shall also speed up developing new home digital entertainment products as next-generation high-density laser video display. By the end of the Eleven Five-Year Plan Period, the transform from the simulation-technology based audio & video industry to the digital-technology based audio & video industry will be basically accomplished, and the annual sales revenue of this industry will amount to 650 billion Yuan" (NRDC, 2006, p.9, emphasis added).*

The importance of work on AVS standard is also implied by the Chinese policy aimed at diminishing the dependence on foreign intellectual property – the issue pertaining to the MPEG-AVS standards competition:

> *"To safeguard the industrial safety, we shall change the situation in which key technology is restricted and core products have to be imported from other countries.* ***Independent development*** *shall be realized by strengthening* ***independent innovation*** *and making breakthroughs in technique" (NRDC, 2006, p.5, emphasis added).*

> *"Aiming at building information infrastructure of* ***next-generation network*** *and raise national information ability, keep on constructing and completing backbone network of next-generation network that covering the whole nation. Set up related technical standards and promote them becoming international standards, and carry out industrialization of key equipment, core devices, and key software" (NRDC, 2006, p.22, emphasis added).*

3. Technical, political, and economic background for the case

To understand the dynamics of standards development, political, economic, and political contexts in which the development of standards takes place must be analysed. Without the contextual examination of the standardisation arena any analysis attempts will remain partial and superficial at best.

3.1. Development of the Chinese industry

3.1.1. The key policy issues of the National Development Plan

Certain policy issues, as emphasized in The eleventh five-year plan of the development of hi-tech industries of the Chinese National Development and Reform Commission (NRDC, 2006) bear a direct importance in shaping the context for the development of audio-visual codecs, and the work of AVS specifically.

Underpinning technology and customer demand is the government's determination to bring about convergence. In its Eleventh Five-Year Plan, China has defined the goal of fostering convergence of the telecom companies, Internet players, and cable TV networks, in order to strengthen the construction of information infrastructure, such as broadband communications networks, digital TV networks, and next generation Internet (Tse & Artero, 2007, p.3).

The following excerpts from the Plan should be motioned:

- **Next Generation Networks.** Emphasis shall be put on the cultivation of such emerging industrial clusters as next-generation network, new-generation mobile communication, digital TV (NRDC, 2006, p.8);
- **Independent innovation.** The independent innovation as the strategic base point in the development of Hi-tech industry should be pursued. Core technology with intellectual property and independent brands should be fostered (NRDC, 2006, p.6).
- **Strengthen the construction of information infrastructure.** Strengthen the construction of communications, broadcasting, and internet; actively boost "convergence of the three networks". Focus on building and perfecting broadband communication network, accelerate the development of broadband access network, steadily boost the construction of new-generation mobile communication network, and strengthen the construction of international communication network (NDRC, 2006, p.14).
- **Cultivation of digital video industry.** Boost digitalization of audio and video industry, construct national engineering and researching center for digital TV, focus on developing basic technologies, common technologies, new technologies as IPTV and handset TV, etc. Boost industrialization of digital broadcasting and TV equipment, digital home network, digital audio and video terminal products, next-generation high-definition large capacity optical disc. Build a digital broadcasting and TV network. Forcefully develop digital content, and promote basic business and value-added business of digital TV (NDRC, 2006, p.22).
- **Actively develop digital content industry.** Strengthen the development and usage of information resources, forcefully develop digital content industry that carries forward nation's advanced culture, meets people's need, and promotes the development of economy and society. Protect intellectual property rights of digital content products abiding by laws (NDRC, 2006, p.15).
- **Development of audio-visual CODEC standards.** Reinforce research, establishment and promotion of digital audio& video relevant standards. (NDRC, 2006, p.22). Wash out unprogressive standards, and encourage industry, university and research institutes to work out key technology

standards jointly, support enterprises and corporations in independently making and participating in making international technology standards, promote China technology standards becoming international standards, and accelerate the transformation from foreign advanced standards to domestic standards (NDRC, 2006, p.26).

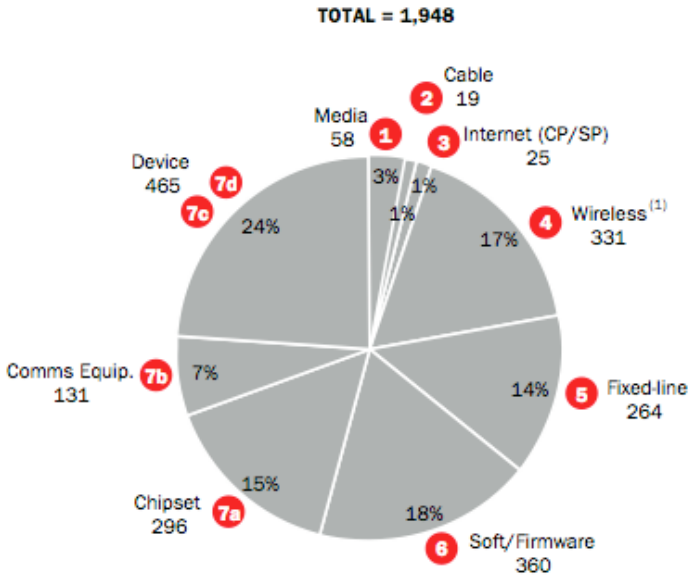
3.1.2. The key industrial indicators

It makes sense to juxtapose the official rhetoric on the importance of endogenous innovation, especially in the domain of hi-tech industry – creation of all-IP infrastructure for the creation and delivery of audio-visual content – to the actual development of the Chinese key industry sectors.

In 2005, the sales revenue of Hi-tech manufacturing amounted to 3.4 trillion Yuan, the added value of which accounting for 4.44% of China' GDP with an average annual growth rate of 27.5% during the Tenth Five-Year Plan Period (NRDC, 2006, p.3). The export of Hi-tech products reached US$218.3 billion, six times that of the end of the Ninth Five-Year Plan Period, accounting for 28.6% of the nation's gross export. Such Hi-tech service industries as network industry and digital content industry witnessed a rapid development (NRDC, 2006, p,3).

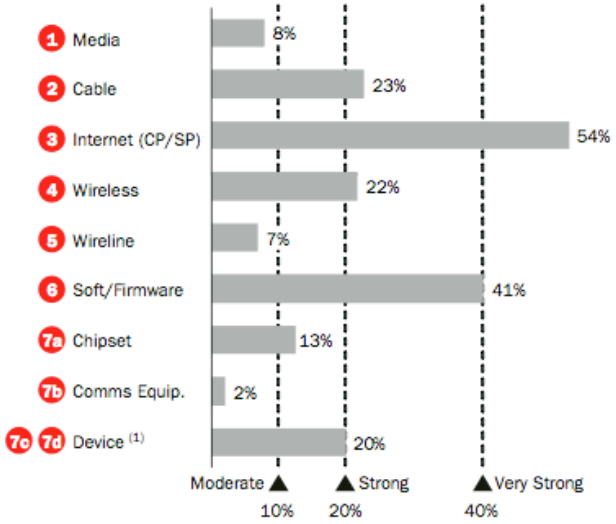
A recent study by Booz Allen Hamilton (Tse & Artero, 2007) has identified seven main sectors within China's telecommunications and information industries in the convergence space: media, cable, Internet, wireless, fixed-line, software, and hardware (with subsets of devices, communications equipment, and chipset within hardware), with total annual revenue of 1,948 billion Yuan (2005). It is important to note that the revenue is unevenly distributed: the top five sectors in terms of annual revenue are devices, software, wireless, chipset, and fixed-line – comprising more than 85 percent of total revenue (see Figure 1).

Figure 1. Cross-Industry Revenues (2005 Bn Yuan). Source: (Tse & Artero, 2007, p.4).



Sectors with the largest annual revenue are not necessarily the ones with the highest growth rate. The Internet sector has enjoyed the highest annual growth, followed by the software sector, the cable sector, and the wireless sector. On the other hand, the media, the fixed-line, and the communications equipment sectors have the lowest growth rates of 8 percent, 7 percent, and 2 percent respectively (see Figure 2).

Figure 2. Cross-Industry Growth Rate (2004-2005). Source: (Tse & Artero, 2007, p.4)



As the current analogue network is scheduled to be replaced in 2015, media providers will have to refine a digital network strategy to fulfil their DTV and Internet Protocol IPTV ambition (Tse & Artero, 2007, p.4), which will mean big times for audio-visual CODEC standards, whether it be MPEG4/H.264 series or AVS.

The move towards NGN has certain implications most, if not all, ICT industry players. Communications equipment companies should embrace the goal of seamless voice, data, and video delivery anytime and anywhere by supporting fixed and wireless broadband technologies. Companies should also develop innovations to support high-quality IPTV and introduce value-added services (Tse & Artero, 2007, p.11). The importance of value-added services is stressed in the National Development Plan, too, stating that there is an imperative "to transfer from production-oriented value-added tax to consumption-oriented value-added tax" to further strengthen the driving force of Hi-tech industry development (NRDC, 2006, p.5).

The shift in "tax" from production to consumption can be explained by the complexity of the NGN (manufacturing) paradigm on the one hand, and the demand-driven conditions for ICT industry in China on the other hand, where the two factors also bear the effect of the "triple-play" convergence of the Internet, TV, and telecommunications domains. China has the world's largest mobile communication market and Internet market. The total number of mobile subscribers in China reached 640 million in 2008, and the mobile phone penetration rate was 48.5% (NBS, 2007). The number of Internet users in China reached 298 million in 2008, which exceeded the number of the U.S. for the first time; the penetration rate of Internet service in China is 22.6%, which is just above the world's average level (Hu & Lv, 2008; NBS, 2007). The future trend of ICT industry is mobile broadband and wideband mobility,

which shows the huge potential market demand in ICT industry of China (Hu & Lv, 2008).

3.1.1. Standardisation arena in China

The EU and China have a different focus on standards setting and IPRs (Ure, 2006). For the EU, harmonization of practice and policies across Member States has been the primary goal. In contrast, China has seen the standards setting process and IP as primarily serving the goals of national development (Ure, 2006, p.29).

The techno-political context established by the National Plan, and the development of the Hi-tech industry in particular, allows to better understand motivation for China pledging to adopt 2,000 international standards a year for the first five years of the Tenth Five-Year Plan to reach the target of 80 per cent of 'key' industrial standards conforming to international standards (Ure, 2006, p.18). By the end of 2002, China had 8,931 national standards based on international standards. Of these 42.4 per cent (or 3,794) were not equivalent to international standards. Only 2,169 were identical, and a sizeable portion (2,968) were modified versions of their international counterparts (Weeks & Chen, 2003, p.4).

While 'key' industrial standards are important in the context of export strategies, the strong emphasis on the development of endogenous Hi-tech industries requires development of home-grown standards, too. The drive for home-grown standards can be explained by significance of royalty payments in China's case by the sheer volume of ICT products involved. According to OECD data, China (US$180 billion) overtook the United States (US$149 billion) as the world's largest exporter of ICT goods in 2004 (OECD, 2004; Ure, 2006, p.2). In 2001, over 50 per cent of all China's exports were by foreign-invested enterprises, and by 2005 'exports by foreign-invested enterprises accounted for 58.5% of China's total foreign trade, the corresponding figure for state-owned enterprises was 25.7% (General Administration of Customs, 2005).' (WTO, 2006). In the case of high-tech exports the percentage is even higher, accounting for 88 per cent, according to China Economic Quarterly (FT.com, 2006).

Creation of large scale endogenous and independent innovation (and standardization by this token) requires a well functioning bureaucratic infrastructure to support, maintain, and protect (the IPR of) the national standards, and well-trained staff to undertake the R&D.

Standardization Administration of China (SAC) is at the top of the standards infrastructure hierarchy. SAC has vice ministerial status and is part of the Chinese General Administration of Quality Supervision Inspection and Quarantine (AQSIQ). SAC was established to develop the Chinese standards agenda and help bring domestic standards into alignment with international standards (R. Suttmeier & Yao, 2004, p.25). AQSIQ emerged out of the reorganization of China's standards system in 2001 that followed WTO accession. SAC serves as China's "national body" at most international standards organizations (such as the ISO and IEC) and oversees the administration of the national standards system (R. P. Suttmeier *et al.*, 2006 p.13).

Besides the flagship CSA, some 12 national level and 257 local level standardisation associations have also emerged in recent years, including the China Association for Standardisation (R. P. Suttmeier et al., 2006, p.14).

In spite of considerable change in the Chinese standards regime, "the changes are as much about installing a system that bolsters the competitiveness of Chinese products in overseas markets as conforming to international practices (R. Suttmeier & Yao, 2004, p.26). Such situation creates a playing field for head-to-head competition of the home-grown AVS and international MPEG/H.264 audio-visual CODEC standards.

In terms of protecting the endogenous (and foreign) IPRs, there is a number of state bodies responsible for implementing IPR protection. This includes approving and monitoring national and industry standards which include essential local IPRs together with foreign-owned IPRs associated with international standards. The list of bodies is rather long, suggesting a complex setup (Ure, 2006, p.19):

- National Reform and Development Commission (NDRC)
- State Intellectual Property Office (SIPO)
- State Administration for Industry and Commerce (SAIC)
- General Administration for Press and Publication (GAPP) - includes the State Copyright Bureau
- Ministry of Information Industries (MII) + Communications Standards Research Institute of China Academy of Telecommunication Research
- State Administration for Radio, Film and Television (SARFT)
- Ministry of Culture
- Ministry of Commerce (MOFCOM)
- Ministry of Public Security
- General Administration of China Customs
- Supreme People's Court
- Supreme People's Procuratorate
- Administration for Quality Supervision Inspection & Quarantine (AQSIQ)
- Standardization Administration of China (SAC)
- China National Certification Accreditation Commission (CNCAC)
- China Electronics Standards Institute (CESI)
- China Communications Standards Association (CCSA)

Looking at the R&D capability as constituted by the well-qualified staff, the total number of R&D staff in China reached 1,736 thousand in 2007 (Hu & Lv, 2008; MSTPRC, 2008) – the percentage still very low compared with the population gross. The total R&D investment in China reached 48.8 billion USD, which ranked the 4th globally, however the gap between China and developed countries is still huge (Hu & Lv, 2008; MSTPRC, 2008). The investment in fundamental research in China was only 2.29 billion USD in 2007, with a percentage of 4.7% compared with the total 48.8 billion USD R&D investments, representing some 20% of that figure in developed countries (Hu & Lv, 2008; MSTPRC, 2008). The total number of authorized innovation IPRs reached 68,000 with a 4th worldly ranking in 2007, and the total amount of scientific papers cited by the major three search engines (SCI, EI,

ISTP) reached 172,000 in 2006, with a ever-growing global percentage of 8.4% (Hu & Lv, 2008; MSTPRC, 2008).

4. AVS and the Chinese Hi-Tech market

4.1. AVS

In their excellent review of the Chinese national standards strategy, Suttmeier et al. (2006) provide an account of AVS work from its very inception. This section builds on much of that work.

The beginning of work on Chinese audio-visual CODEC dates back to 2001, when China (with representatives from the Institute of Computer Technology of the Chinese Academy of Sciences, Tsinghua University, and Microsoft Research Asia) began to participate in the work of the Joint Video Team (JVT) of the ITU. A central concern of the Chinese specialists in these activities was control over intellectual property and the excessive license fees that seemed to attend to the next generation of audio video standards. In May 2002 a group comprised of 24 international companies and 7 Chinese firms began to explore the possibilities of developing a royalty-free standard. The establishment of the AVS Working Group followed shortly thereafter with the expectation that close cooperation with MPEG-China would be maintained. At the June 2003 meeting of JVT, Gao Wen's group at the CAS Institute of Computer Science was given the lead for the development of video coding software (R. P. Suttmeier et al., 2006, p.20).

The development of AVS has received high-level review and approval from the Ministry of Science and Technology's Department of High and New Technology, CAS's Bureau of High-Technology Research and Development, the Chinese Academy of Engineering's Division of Information and Electronic Engineering, and MII's Department of Science and Technology. Progress has continued on the various standards that comprise the AVS package and AVS-P2 video part of AVS standard has been approved as a national standard in 2006 (R. P. Suttmeier et al., 2006, p.20).

In the AVS case, the state intervened in order to facilitate the organization of the AVS working group. The work of the AVS group has, however, apparently proceeded largely independent of the state. The state has never supported AVS WG directly. The relevant R&D activities were conducted by member players, some of them, especially the public research or education institutes, have projects funded by National science foundation, etc. Foreign companies have also been involved in the development of the standard (R. P. Suttmeier et al., 2006, p.34).

In the first critical commercial test of the standard, however, in a procurement decision by SARFT, the state actually backed away from the indigenously developed Chinese standard and opted for the more familiar, but arguably technically inferior, MPEG2 international standard (R. P. Suttmeier et al., 2006, p.34). Such policy action implies that the interest of the Chinese state in standards is by no means straightforward and unambiguous. Though the state is clearly committed to the development of Chinese standards, there remains both a diversity of interests within the state regarding particular standards and a diversity of policy tools (such as regulation, procurement, and R&D support) that can be employed in the implementation of standards policy (R. P. Suttmeier et al., 2006, p.34).

So what factors affect the policy decisions with regard to competing CODEC standards? Probably the most-quoted factor is that of IPRs. AVS backers say the Chinese standard could save domestic companies a lot in royalties. These claims date back to the times when AVS work was conceived – 2001/2, when the issue of high royalty fees for DVD/MPEG-2 was on agenda. With the development and introduction of the next generation international CODEC standard, MPEG-4/H.264, the royalty fees have been lowered on average from US$4 to US$2.5 per device, although the charging model became more complex, and the burden of fees has spread from "manufacturers-only" in the case of MPEG-2 to include content and service providers in the case of MPEG-4/H.264. It is estimated China will pay 20 billion to 50 billion Yuan each year if H.264 is adopted.[7] AVS patent holders, on the other hand, charge only 1 Yuan for every consumer-level decoder unit. Licence commitments must be made by any contributor to AVS. If for MPEG-4/H.264 IPR contributors RAND is the only option, IPR contributors to AVS can choose between AVS patent pool or RAND-RF (royalty free). But H.264 is more mature with wider industry support (ChinaDaily.com, 2007c).

Besides being cheaper than its rival MPEG CODEC, AVS is claimed to be better than many of today's video standards (IEEE Spectrum, 2007). By 2007 the AVS working group had 158 members, including some 28 percent from organizations headquartered outside China (IEEE Spectrum, 2007). The group is diverse and encompasses computer hardware and software manufacturers, telecommunications manufacturers, consumer electronics companies, semiconductor chip design firms, and universities and research organizations. Most of these member organizations put some intellectual property into the pool either for sharing or licensing at a low cost. With so much intellectual property to draw on, the AVS working group was able to use technologies with higher coding efficiency, that is, providing higher quality at a lower bit rate, than older standards, like the MPEG-2 standard used for DVD. AVS performs comparably to contemporary standards, such as H.264 (IEEE Spectrum, 2007), but has an outstanding advantage of requiring less computational power for the same level of performance as compared to H.264, which makes it a preferable standard for the mobile applications.

English translation of the AVS standard became available in September 2007, along with the IPR policy (The c10.Info Archives, 2007). Availability of the English translation gives chipmakers possibility to start offering support for AVS CODEC to be used in the Chinese domestic IPTV, satellite and the cable TV market (The c10.Info Archives, 2007).

As of today, AVS Industry Alliance consists of 18 firms:

TCL Corporation; Beijing Haier Broad-Tech Digital Technology Co. Ltd; Skyworth Research Institute; Huawei corporation; Hisense corporation; Langchao corporation;

[7] For the next generation of high-definition DVDs using MGEP-4 and H.264 standards suitable for High Definition TV (HDTV) and Internet Protocol TV (IPTV) over broadband networks as well as for home next generation DVD players, royalties on coders-decoders (codecs) have been fixed at US20 cents per unit over and above 100,000 manufactured units and at US10 cents per unit above 500,000 manufactured units, up to a maximum of US$3.5 million per enterprise 2005-2006, US$4.25 million 2007-2008 and US$5 million 2009-2010. Where enterprises produce codecs for PCs, either under their own brand or for other companies, the caps are set at US$10.5 million 2005-2006, US$11 million 2007-2008, and US$11.5 million 2009-2010. By contrast, the royalty to be charged on China's home-grown competing Audio-Visual Standard (AVS) CODEC is thought to be US1.2 cents per unit (Ure, 2006, p.2). Royalties on content include fixing US0.2 cents per title. Royalties are agreed with MPEG LA. For full details, see 'MPEG-4 Royalties Revealed', 18 November 2003, contributed by ByteEnable at: http://www.linuxelectrons.com/article.php/20031118211505452.

National source coding center; Mobile Communication Association in Pudong District; Changhong corporation; Central Research Institute, SVA; ZTE corporation; Zhongguancun Association for High-Tech Enterprises; Xiamen Overseas Chinese Electronic Company Ltd.,; Celestial Semiconductor Corporation; Sinocon Industrial Standards Foundation; Sunniwell Broadband Corporation; Taovo Technology corporation; Penstar Technology International Co. Ltd.

A number of firms in different technology domains have adopted AVS. AVS-based products include handset, IPTV STB (set-top-box), chips, terminal device, editing system, etc. There are both Chinese and Foreign manufacturers engaged in AVS-based products market. 4 Chinese players with 6 foreign players manufacture AVS Chips, 3 Chinese and 1 US corporations make AVS encoders. Besides, there are 5 Chinese corporations producing IPTV devices, including HUAWEI, ZTE, TCL, etc.

AVS Encoders are produced by SumaVision (Beijing) Co. Ltd.; United Source Coding Audio & Video Technologies (Beijing) Co. Ltd.; Envivio Inc.; SVA Information Industry Co., Ltd.

AVS Chip Manufacturers include: Spreadtrum Communications; Shanghai Longjing Microelectronics Co. Ltd.; Broadcom Connunications Technology(Shanghai)Co.,Ltd.; NXP Semiconductors; ST Microelectronics(Beijing) R&D Co. Ltd.; Sigma Designs, Inc.; Hangzhou Nationalchip Science & Technology Co., Ltd.; C2 microsystems, Inc.; Celestial Semiconductor (Beijing). Co., Ltd.; Chips & media

Terminal Equipment Manufacturer: Hisense Company Limited; Microunit Technology; Jiangsu Yinhe Electronics Co., Ltd; SVA Information Industry Co., Ltd; Shenzhen Leaguer Digital Television Technology Co.,Ltd.; Shenzhen Hitone DVB Technology LTD; Changhong Electric Co.,Ltd; Sichuan Kingvon Electronic Technology CO.,LTD.; DVN Group; Wanlida Group Co., Ltd.

AVS-based IPTV Equipment (including stream media server, services management system, STB, etc) Manufacturers: TCL Corporation; Sunnlwell Broadband Network Information Technology Ltd.; Hisense Co., Ltd.; Huawei Technologies Co., Ltd; ZTE Corporation

AVS Video Surveillance Equipment Manufacturers: Vimirco Corporation; FiberHome Technologies Group; Beijing Fullingstar Elcetonical Co.,Ltd.; Hangzhou Hikvision Digital Technology Co., Ltd.; Shang Institute, CAS, Institute of Computing Technology; Tianjin Tiandy Digital Technology Co., Ltd.; Zhejiang Dahua Information Technology Stock Co.,Ltd.

AVS Editing Equipment and System (development tool): Beijing AVSolutiontech Technology Co., Ltd.

4.2. Use of AVS in different technology / business domains

4.2.1. IPTV

IPTV is defined as multimedia services such as television/video/ audio/text/graphics/data delivered over IP-based networks managed to provide the required level of QoS/QoE, security, interactivity and reliability (FG IPTV, 2007).

IPTV is one of the services known as "triple play" – capable of delivering voice, video, and data to consumers. IPTV is aimed at providing broadcast-level service offerings on IP-based networks by enhancing quality, delivery control, and so on

(TTC, 2007). Given its requirements, IPTV is seen as an application that will be best implemented in the Next Generation Networks (NGN) environment. Expectations are high for IPTV to become one of the first practical NGN applications (TTC, 2007, p.1).

The rapid spread of broadband communications and digital broadcasting over the last several years around the world is a major factor in the advent of IPTV service. Its standardization has been promoted with both the telecommunications and broadcasting industries taking the initiative (TTC, 2007, p.27).

Since the broadcasting service is a huge business and intrinsically region-oriented, there is a tendency for each region to advance IPTV standardization independently, often resulting in de facto standards. On the other hand, the use of IP has broadened the target of services on a global scale, and IPTV is expected to become one of the future killer applications of NGN. For these reasons, the standardization of IPTV involves struggles over leadership and interests among regions and industries (TTC, 2007, p.27).

In the field of broadcasting, ATIS of the U.S. and DVB of Europe, both of which have been promoting digital TV broadcasting, have dominant presence. Both organizations have study groups specializing in IPTV and are working actively to develop standards in a vast range of area, from architectures to service specifications, including submitting proposals to the ITU-T. As for telecommunications-related fora, FG-IPTV, established in the ITU-T in April 2006, is playing a pivotal role in standardization. The purpose of the ITU-T FG-IPTV is to coordinate and promote the development of international IPTV standards while working in collaboration with existing fora and other organizations concerned (TTC, 2007, p.46). MII of China is acting as a vice-chairman for the FG, along with two other organizations: BT (UK) and ETRI (South Korea) (TTC, 2007, p.46). Many fora are working in conjunction with this group (TTC, 2007, p.27). There are six working groups (WG) under the FG-IPTV at ITU-T, each dedicated to a specific target field:

- WG1: IPTV service requirements and architecture. Leaders: South Korea Information and Communications University (South Korea), France Telecom (France), Alcatel-Lucent (France).
- WG2: IPTV service quality and performance. Leaders: Canada, Siemens (Germany)
- WG3: Service security and content protection. Leaders: **ZTE (China),** DELL (Switzerland), Samsung (South Korea).
- WG4: Network control. Leaders: Korea Telecom (South Korea), UTStarcom (U.S.)
- WG5: Terminal systems and interoperability. Leaders: **China Telecom (China)**, Cisco (U.S.), NTT (Japan).
- WG6: Middleware applications and content platforms. Leaders: NTT (Japan), DTI (UK).

Chinese AVS forum contributes to “Common Technologies” section, MPEG4 subsection of FG IPTV (TTC, 2007, p.57). The only other contributing for a to MPEG4 subsection is MPEGIF.

Currently, the ITU-T FG IPTV is playing a pivotal role in developing international IPTV standards. All the IPTV-related fora mentioned earlier are the liaison organizations of the ITU-T FG IPTV. Another IPTV-related international standardization body is ISO/IEC JTC1. Its SC29 WG11 (MPEG), which works on coding of audio, picture, multimedia and hypermedia information, is closely related to IPTV (TTC, 2007, p.74).

Of the regional standardization bodies, ETSI in Europe and ATIS in the U.S. are keen on IPTV standardization. ETSI published the DVB's Phase 1 deliverable as ETSI TS 102 034 v1.1.1: *Transport of MPEG-2 Based DVB Services over IP Based Networks (2005.3)*. The ATIS/IIF develops specifications for offering seamless end-to-end solutions to a range of users from content, service, and network providers to consumers. This forum is contributing to the ITU-T FG IPTV, especially with relation to IPTV architectures. Meanwhile, TTC has begun work on IPTV by organizing an IPTV working group (TTC, 2007, p.74).

The motives driving the ITU-T toward standardization are numerous. First, when telecom carriers with large market share provide a service, it is obviously vital for the technology they use to be in compliance with an international standard, in order to meet the WTO TBT principles (TTC, 2007, p.81). Also, the ITU-T is important as an international standardization body to equipment vendors that conduct business on a global scale and companies that distribute content across the world. It seems that the intentions of the ITU-T, which needed a driving force to attract attention to NGN standardization, coincided with those of enterprises seeking to deploy NGN-based services globally. It is still premature, however, to conclude that NGN-based services are indispensable to the IPTV business (TTC, 2007, p.81).

By 2007, only four IPTV licenses have been issued in China[8] – to Shanghai Media Group, China Central Television International, Southern Media Corporation, and China Radio International (ChinaDaily.com, 2007a). Shanghai Media Group was the first company in China to receive a license from Beijing to run IPTV (ChinaDaily.com, 2006b). China's largest fixed-line company, China Telecom Corp., and Shanghai Media Group in September 2006 launched a joint Internet TV service (ChinaDaily.com, 2006b).

China Telecom and China Netcom have been aggressively building trial IPTV networks since 2005. Since 2006, some commercial IPTV services have been operational in cities such as Shanghai (ChinaDaily.com, 2006a). In 2006 China Telecom had 210,000 IPTV subscribers, with 70 percent of them in Shanghai (ChinaDaily.com, 2007c). The market for IPTV was expected to take off in China in 2007 as fixed line operators sought ways to grow (ChinaDaily.com, 2006a).

In an interview with China Daily on the sidelines of the ITU Telecom World 2006 in Hong Kong, Huang Dabin, vice-president of the network division of China's No 2 telecoms equipment maker ZTE Corp., predicted the number of IPTV subscribers in China could exceed 1 million in 2007 year, up from 100,000 subscribers in 2006 (ChinaDaily.com, 2006a). The actual number of IPTV subscribers in China reported by the end of the third quarter of 2007 was somewhat short of the earlier forecasts -

[8] Somewhat confusing, other sources report on five operators of IPTV services in China as for 2007: UTStarcom, the largest supplier with a 46% share of the market. Chinese operator Vcom, with a 36.6% share. ZTE (Chinese), with a 13.9% of the market. Huawei Technologies (Chinese), with 3.2%, and Alcatel Shanghai Bell with 0.3% share of the market (IPTVwatch, 2007). Interestingly, this source doesn't list either China Telecom or China Netcom as IPTV service providers.

840,000 (IPTVwatch, 2007). Different companies give very different estimates for the market growth in the future. Market research firm In-Stat predicts that China will have about 4.5 million IPTV subscribers by 2008 (ChinaDaily.com, 2007b). US research firm's IDC forecast for the IPTV subscribers' number was 10 million by the end of 2008 and 23 million by the end of 2010 (ChinaDaily.com, 2007a). iSuppli predicts 17 million IPTV subscribers by 2011 (ZDNet.com, 2008). The actual number of IPTV subscribers by the end of 2008 reached 2.6 million (CCID Report, 2009).

The development of IPTV in China hinges on the industry's ability to meet customer demand (ChinaDaily.com, 2007a). Besides, there are regulatory issues. Already in 2007 China Telecom and China Netcom called for the deregulation of the IPTV market, which could give a major boost to the broadband Internet business of these two fixed-line carriers – by 2007 regulators have only allowed China Telecom to offer IPTV commercial services in six cities, preventing it from reaching millions of potential customers across the country (ChinaDaily.com, 2007b). The overlapping responsibilities and different goals of broadcasting regulators and communications regulators have restricted the development of "Triple TV"[9] (ChinaDaily.com, 2007b).

In some cases there are conflicts of economic interests with the government agencies who have policy responsibility for their industry sectors. The TV market is a case in point. On the one hand SARFT (State Administration for Radio, Film and TV) came into conflict with regional cable network operators who resisted efforts to consolidate them, and on the other hand SARFT (network content) resisted efforts by the MII (network transmission) during the 10th 5-Year Plan to promote the idea of convergence between telecom and cable networks. The same tensions seem to have carried over to IPTV trials. SARFT has restricted authorization to carry out tests to the Shanghai Media Group in conjunction with China Telecom and China Netcom (Ure, 2006, pp.11-12).

4.2.2. HD-DVD (CBHD)

Shanghai United Optical Disc in July 2008 completed the first production line for CBHD (China Blue High-definition Disc), a high-definition optical disc format, which comes with a substantially cheaper copyright royalty fee than its global rival Blu-ray disk (The Hollywood Reporter, 2008) and will allow the national manufacturers avoid royalty claims from the U.S. and Europe (The Hollywood Reporter, 2006). Drive producers believe the format will have a hard time competing against Blu-ray, which already has made a move into the Chinese market. While acknowledging Blu-ray's dominance, Hideki Ono, general manager of Shanghai United Optical Disc, told The Hollywood Reporter that there is still enough room in the Chinese market for the new format to grow (The Hollywood Reporter, 2008).

In 2007 the steering committee of the DVD Forum has approved the final draft of a memorandum of understanding with the leading Chinese developer of optical discs, paving the way for the creation of a Chinese HD-DVD format (MovieWeb.com, 2007). This could have lead to very inexpensive HD-DVD players, not just in China, but the rest of the world. This memorandum with China's Optical Memory National Engineering Research Center, marked the first time China was participating in a standardization process for content within a global entity, the DVD Forum, which

[9] Triple TV is an industry term describing the ability to offer voice, data and video across fixed and mobile telephone networks.

also gives its stamp of approval to standard DVD (MovieWeb.com, 2007). However, HD-DVD having lost the standards' war to its rival Blu-ray[10] (CNN.com, 2008), the opportunity window for the Chinese CBHD establishing itself as a global standard could have been lost for a while.

4.2.3. DTV (DTTB/DTTV)

The China Digital Television Terrestrial Broadcasting (DTTB) System Standard, also known as GB20600-2006, became the mandatory national DTTB standard in August

2007 (eetindia.com, 2009). The technology can broadcast audio and video at transmission to stationary and mobile consumer devices.

A key enabler for the GB20600-2006 China DTV standard for mobile broadcasts is Multi-Protocol Encapsulation (MPE). In a standard broadcast system, the encoded audio and video data is in an Transport Stream. The MPE is a mechanism for transporting Internet protocol (IP) data on top of this Transport Stream. The MPE GB20600-2006 program content, which is delivered as IP streams, can be encoded in both AVS and H.264 standards (eetindia.com, 2009).

According to the State Administration of Radio Film and Television of China (SARFT), the digital terrestrial television (DTTV) network will cover all over China in three years (SinoCast.com, 2009). The rollout of the network is planned to be done in two phases. Firstly, both high-definition programs of China Central Television (CCTV), the nation's largest national television operator, and standard-definition television (SDTV) programs are scheduled to be broadcast in 37 major cities across the country; and then, SDTV programs will be watched in its 333 cities and 2,861 counties (SinoCast.com, 2009). The rollout will be supported by the Chinese government's CNY 2.5 billion (SinoCast.com, 2009).

There is a TV user base of 400 million in China including 150 million urban cable TV users, giving China a potential digital TV user base of 250 million (SinoCast.com, 2009).

Because AVS is not an obligatory standard, however, the higher TV user base does not translate directly into high adoption rates for AVS.

As of today, the market share AVS in DTV domain is still very low. For DTV, in 2005 CCTV announced adoption of MPEG-2/DVB not AVS. Such a decision may have been predicated on the fact that in 2005 AVS was not yet an established national standard. As of today, Shanghai has launched territorial digital broadcasting based on AVS. There are more than 30,000 subscribers by May, 2009.[11]

While the detailed coverage of the development of mobile broadcasting standards is reported in Deliverable 10 (D10), here it is important to mention that standards competition is present in that domain, too, as constituted by CMMB standard for Multimedia (TV/Video) Mobile Broadcasting. As reported in D10, by April 2009 CMMB tests had been performed in 37 major cities in China. With its subsidiary and

[10] In February 2008, Wal-Mart and online rental company Netflix said they would abandon HD-DVD in favor of Blu-ray. One month earlier, Warner Brothers Home Entertainment - which had been the largest media company releasing videos in both formats - announced it would offer DVDs solely in Blu-ray. These moves tipped the market support to Blu-ray, necessitating Toshiba abandon its HD-DVD standard (CNN.com, 2008).

[11] As reported by China Electronics News, 2009-05-14.

major Chinese CMMB operator "China Satellite Mobile Broadcasting Corporation" (CSMBC), an impressive rollout of CMMB networks nationwide has been committed. In mid-May 2009 it was reported that CMMB networks are deployed in 174 cities (CMMB, 2009), and the SARFT plans to be able to offer coverage in 337 cities by the end of the year (ChinaTechNews.com, 2009). Important for this discussion, CMMB standard incorporates both AVS and H.264 as its source-encoding technologies. However, a question remains whether AVS will be actually used in the future services, or will remain as a symbolic reference in the list of supported standards.

5. Future trends/ developments

On the backdrop of the prominence of NGN rubric at the international (ITU) and national (China) level, the build-out of all-IP digital infrastructure, and the need for interoperability of the digital content across sites, technology domains, and user devices, and the complex setup of the Chinese standardisation arena, it is rather given than not that competition between AVS and MPEG-4/H.264 will take new interesting turns in China and globally.

Specifically, we can outline a number of domains where the established dominance of MPEG-4/H.264 can be "threatened" by the rising popularity of lower-royalty-bearing and lower-computational-power-requiring AVS:

- The Internet/Web-based video sharing (there already are Chinese alternatives to YouTube: www.youku.com and www.tudou.com).
- The High Definition Disk domain (the Chinese AVS-based CBHD will support H.264-based Blu-ray format, while bear lower royalties for the manufacturers and users).
- The IPTV domain (Depending on IPTV market regulation endeavours, we may see either a boost in competition between the two standards, or one being mandated while the other being faded out).
- Mobile multimedia/video broadcast domain (presently CMMB standard allows for both H.264 and AVS encoded content broadcast, while in practice only H.264 is used. Given the business and techno-political importance of the mobile domain, interesting twists and turns can be expected in the CODEC standards competition on this arena).

While in the domain of Internet/Web-based digital video content AVS will have to fight hard to establish itself as an alternative to already dominant H.264, the latter two technology domains may flip easier to favour AVS.

The competition between the two CODEC standards will be supported by the internationals standardisation arena, where AVS-P2 has been listed as just one of the three video codecs in Draft Recommendations of FG IPTV under ITU-T (the other two are AVC-1 and H.264) (ITU FG IPTV, 2006).

However, the while on the global standardisation arena the timeframe for competition between different CODEC standards may be indefinitely long, in China non-AVS codecs will likely (or certainly) be phased out with the advent of new technologies (see Table 1). The nation-wide switch from analogue to digital TV broadcasting system is planned for 2015 in China, leaving some time for the "battle of standards"

to evolve. As depicted in Table 1, from today's perspective AVS seem to has better chances to come as a winner in this battle, with maybe exception of remaining a "niche" standard in the domain of mobile broadcast. However, should standard preferences in all other relevant domains favour AVS, it would be logical to assume that CMMB would switch to AVS as the CODEC standard, provided that the switch would be seamless for end users. Indeed, the seamless-ness of switching from one CODEC standard to another for end users can be (should be) granted, as already today most chips embedded in user terminals (mobile phones, set-top-boxes, etc.) support both MPEG/H.264 and AVS standards. The dynamic development of the standards, thus, in the years to come will unfold in the policy and industrial domains – something we should be watching for and reporting on in the next deliverable.

Table 1. Evolution of audio-visual CODEC standards in China.*

Technology domain	Technology Standard	Incorporated audio-visual CODEC in the current technology generation	Incorporated audio-visual CODEC in the next technology generation
Mobile Multimedia Broadcast (including mobile TV)	CMMB	H.264 (primary)	Not decided
		AVS	Not decided
Terrestrial Broadcast	CTB/DTTV	MPEG-2 (primary)	x
		AVS	AVS
Internet Broadcast	IPTV	H.264 (primary)	x
		AVS	AVS
High-Definition Video Disk	CBHD	H.264	x
		AVS (primary)	AVS

* Source: anonymous interview, Beijing, April 2009.

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Appendix 1. The Patent Pool of H.264

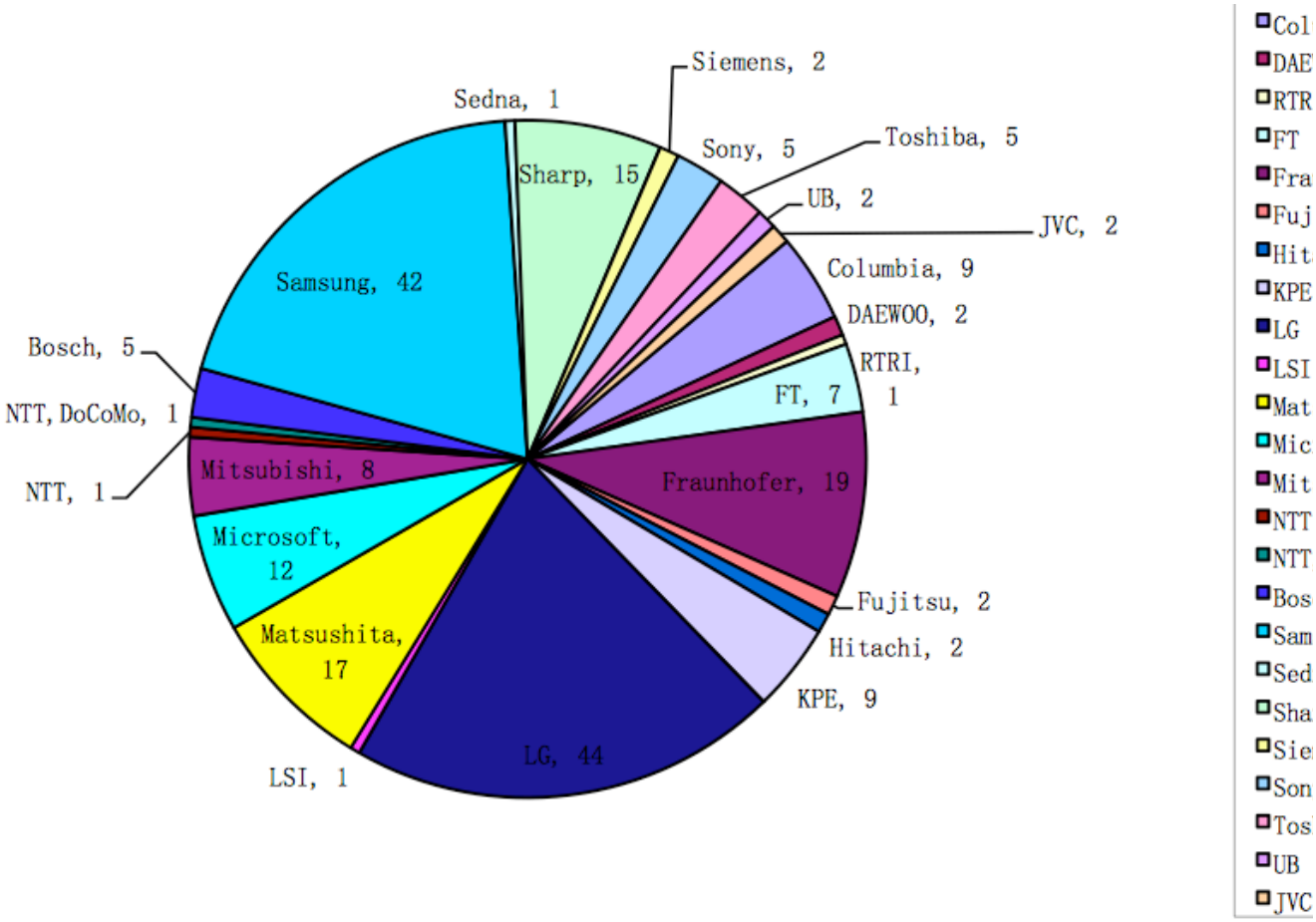

Figure 3. The patent pool of H.264. Source: (SU, 2009)