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Lead Author	James Stewart
Contributing Author	Chengwei Wang (Tsinghua)
Reviewing	Xiaobai Shen (Edinburgh)
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Description

This report describes the empirical study of mobile telecommunications standardisation in the EU and China, including a preliminary analysis of the factors shaping the emergence of these standards.

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Guide to the document

This document is deliverable D11– “Final Report on Standards dynamics in Mobile telephone domain”, created as part of WP4 “Studies of Standards Dynamics: Mobile**”.** It is a report describing the describing the empirical study of mobile telecommunications standardisation in the EU and China, including a preliminary analysis of the factors shaping the emergence of these standards[1]. It focuses on the case of the standardisation of 3G and 4G mobile telephony systems in China, and puts this in the context of mobile telecoms development and deployment in Europe and China. IT addresses primarily the standardisation and implementation of radio access networks in the context of regulatory change, and does not discuss in detail the growing importance in new services and adoption of mobile internet that are likely to have considerable impact on future evolution of the sector.

The report aims to give an overall review of the empirical in addition to an initial presentation of relevant themes for analysis. This adds accumulatively to the findings already presented in “D3: Review of state of Art – EU & China”, and provides input to the upcoming deliverables “D13: Report on Standards Dynamics – Mobile Telecoms” and “D16: Report analysing implications for China and European policies”, and should be read in context of these and other deliverables.

This report is based on industry and academic sources, interviews with selected industry and policy stakeholders in Europe and China. Fieldwork and interviews have been conducted by Chengwei Wang of the Tsinghua University in Beijing, China.

1. Introduction

This document provides an empirical case in the development of mobile telecommunications services. It is triggered by the development of a Chinese 3G mobile standard, referred to as TD-SCDMA (‘TD’), a national alternative to other more widely adopted versions of 3G systems standardised in the 3GPP and 3GPP2 consortia. While this process has been well documented over the last 10 years, it is often reported in very brief terms in commercial, policy and academic literature, much of this concentrated in early part of the decade. During 2009 China finally awarded 3G licences for networks using three different including ‘TD’. Now the attention of policy makers, vendors and operators has turned firmly to the development of next generation of mobile standards, with the emergence of LTE and LTE-Advanced as apparently global standards, but with a continued Chinese telecoms equipment policy singling out a part of the standard, TD-LTE. The report brings together information on some of these latest developments in technology markets, standards and policy in order inform the continual analysis of standards and innovation

The case of ‘TD’ development can be read as the attempted use of a standards process to further the strategic, economic and social aims of the Chinese

[1] Quoted from the *Technical Annex*, section B 1.3.4.10, p. 28.

government. However, as with the a range of Chinese government policies on industrial and social policy, this case shows that this is far from a simple story of a unitary government policy with clear predefined aims. The process unrolled at particular moment in history as China opened some of its previously protected markets by joining the WTO, and attempted considerable reform of government and regulatory policy and practice. The TD story illustrates the determination of the Chinese government to develop indigenous technological capability and a progression along the learning curve of standard making in the context of the technically, commercially and politically dynamic telecommunications market. It also shows unstable goals and interactions of Chinese ministries, and changing strategies of national and foreign commercial players, as they redefine technical 'success' and alternative conceptions of what purpose mobile telecommunications can serve. However, these firms operate in global markets, and the Chinese government is not alone in attempting to balance the creation of markets in services with industry policy to support important national industries.

This report provides a short account of the origins and development of TD-SCDMA, from conception, to deployment in 2009, While this could be viewed as a historical case, the field of mobile telecommunications development, standardisation and use is still highly dynamic, with huge investments and global commercial interests at stake. China is the world largest mobile telecommunications market, with the world's largest operation, China Mobile. In the last decade a number of vendors, notably Huawei and ZTE, have become major international players in equipment supply, and are starting to play an important role in technology development and international standardisation. They appear to have done this in spite of the government policy on 'TD', benefiting from other policies towards trade and joint ventures. We are therefore concerned to learn from the experience of the development of TD-SCMA in China, and use this to help inform our understanding of the development and implementation of the future mobile systems, often known as 4G mobile.
This case can help us address questions in later analytical work such as: Can we use analysis of standards making to understand Chinese policy making? What lessons and experience have Chinese government and industry players drawn from TD-SCMA development, and how may these be used in the future? What lessons and experience have non-Chinese players drawn? Is the development of a 'national' standard a successful strategy for China in an era of global standards? What are the factors that made it possible to develop and deploy a 'Chinese' standard?

1.1. Standards in Mobile Telecommunications

In these documents we are concerned with standards as processes and as artefacts that act as coordinating devices between different actors, commercial and governmental as they pursue a range of strategic and policy aims. We are particularly concerned with standards in relation to innovation. In order to facilitate an analysis of general analysis of standards, some specific details are required on standards in mobile telecommunications systems.

The class of standards most relevant to mobile telecommunications are *Reference Standards.* Organised, formal standards processes are used to develop reference standards, for which a set of compliance assessment processes is developed to ensure that the products of different vendors meet the requirements of the standard. Mobile telecommunications standards have 2 distinct dimensions:

1. Wireless interface standards, which devised to ensure non-interfering use of Radio Spectrum.
2. Interoperability standards to ensure that various parts of the radio and network systems function together, and ensure compatability of equipment produced by various vendors.

Telecommunications has been a state regulated industry from its inception, generally at a national level, but the need for international interconnection has required that common standards have been developed to facilitate interoperability of national networks. The International Telecommunications Union (ITU) has been the principal body where responsible national state bodies coordinate the standardisation of telecommunications. With the gradual privatisation and liberalisation of the telecoms industry in many parts of the industrialised and developing world since the 1970s, telecoms operators and equipment vendors have separated out, creating an international market in standardised telecommunications equipment. This created an increased need for dynamic standards-making processes to ensure interoperability over systems that were no longer so explicitly tied to nation-states. Governments have a number of interested in primary interest in these interoperability standards in terms of industry and social policy: standards as a means of stimulating innovation in services, protecting or supporting national champions, reducing costs to infrastructure developers and end users, and even in broad goals such as nation building[2].

While changes in governance, through privatisation and the disaggregation of telecoms industry has made telecoms standard making much less dependent on State bodies in many countries, unlike many other areas of standardisation, standards related to wireless communication and spectrum use continue to have State involvement. Radio spectrum is universally considered a State-controlled national resource with important strategic and economic value. The State licences use of spectrum bands (or provides for limited, controlled, unlicensed use) with a primary condition that the spectrum user does not cause interference in the spectrum bands licensed to other users. While this could be policed on an ad hoc basis, in practice users are required to demonstrate in advance that the radio equipment they intend use does not cause interference outside their allocated band(s). This demands setting of Reference standards, and ensuing compliance of radio equipment.
Most radio spectrum is occupied by existing users, committed to operating existing radio equipment. New radio services, such as mobile communications require state commitment to release unused spectrum, or claw back existing spectrum. Governments thus need to be convinced that proposed new uses of the national spectrum resource satisfy a minimum of their current strategic, economic or social policy goals. While attempts have been made to allow spectrum owners to decide how they will use spectrum they have licensed, and open up spectrum trading[3] this approach has not developed. Briefly, this means that national governments remain in

[2] Communications infrastructure, from Postal services onwards, have been used to help unite national territories.
[3] ITU ICT Regulation Toolkit http://www.ictregulationtoolkit.org/en/PracticeNote.aspx?id=3076

strong control of the development of mobile telecommunications through their control of spectrum[4].

Governments are generally very enthusiastic about new mobile telecommunications systems for various reasons: they are provided by valuable and dynamic industries; they offer services with apparently strong economic and social benefits; and as the spectrum ‘owner’ they are able to find a variety of ways to profit directly from new mobile services. However, following the economic orthodoxy of deregulation of the last 20 years many governments are stepping back from the direct promotion of new technologies and moving to more market oriented policies with competition of equipment supply and service provision. Governments find themselves in the position of having to deal with intense lobbying from operators, vendors, and emerging players over policy for regulating existing services, and developing future services. There is no obvious organisational or technical solution to policy goals: when different policy goals are pursued by different ministries, each with particular mandates and powers, and historical relationships with industry, then it is surprising if unambiguous policies and planned outcomes actually emerge.

One of the key tensions is between policies that promote competition in telecommunications, and policies to promote innovation in the technologies that are used to build the telecommunications infrastructures. The firms that produce the infrastructure technologies are important wealth generators and employers. System integrators have grown to be major multinational corporations. Many are ‘national champions’ in their home countries. Governments have important roles supporting R&D and providing a range of encouragements/protections for these firms. In parallel, policies to create efficient telecommunications service provision through market and regulatory mechanisms including liberalisation, price caps, privatisations etc, are conducted largely separately to technology industry policy. Standards processes and standards as coordinating objects link these regimes: they are seen as necessary as creating markets in both equipment and services, and in protecting and supporting the firms that create technologies referred to in those standards.. The degree and manner in which governments are involved in standards making and implementation varies internationally, and is under constant review.

While this document focuses on China, it is necessary to make some comment on EU policy towards standardisation of mobile telecommunications to compare trajectories, policy drivers and problems. Standardisation in many forms has been an important part of EU Single Market harmonisation policies, enabling products and services to be sold across the Union, developed in a series of directives since the

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[4] Radio waves do not respect national boundaries, therefore governments have always had to negotiate with neighbouring countries over interference and use. This has usually been coordinated by the ITU-Radiocommunications Sector (ITU-R) Different parts of the radio spectrum have different characteristics – most notably in the degree of propagation of signals. High frequency signals, such as those used by most mobile telephone system, for example travel short distances and require much less cross border coordination than services operating in lower frequency bands. For mobile telecommunication there is another dimension to coordination, that of harmonisation of frequency bands allocated to mobile services to enable the same devices to operate in different countries, and more importantly, provide global markets for standardised equipment, thus reducing overall costs.

1980s[5]. The European harmonisation processes provides us with the classic case of telecommunications standardisation, GSM, that emerged from the coordinated actions of (largely) state owned PTTs in the 1980s (Pelkmans 2001, Fomin 2000).In this case technical harmonisation in the form of standards was the basis of attempts to create a common market in both equipment and services (Pelkmans 2001). The same basic model applies to 3G standardisation in Europe in the 1990s. The core aim of policy makers was harmonisation within Europe, rather than the creation of global standards. However mobile services is only one aspect of telecommunications policy and business. The attempts to create liberal, harmonious markets in telecommunications have continually struggled with the fragmented regulatory system in place, where regulation is largely devolved to a national regulators each with different policy aims and mechanisms. It was only in 1998 that EU members were obliged to set up independent regulators on the 'Anglo-Saxon' model. Few EU Member States have taken the full privatisation route either, many, notably Germany and France, maintaining a large degree of state ownership in old national operators in both fixed and mobile markets, although the majority have considerable private sector competition in mobile (Bauer 2005).

So, while single market competition law plays a powerful rule, there are nonetheless very different approaches in place. This is not helped by an inconsistent European framework either (de Streel 2008). A long consultation process is due to result in new regulatory framework in 2010 creating greater 'targeted' harmonisation (e.g. Cave, M. (2007), de Streel (2008)), and explicitly helping the EU deal with "increased competition from outside Europe" and meeting Commission policy of "the promotion of growth and jobs in Europe"(Commissioner Reding Speech Feb 15 2007[6]). Industry policy in the form of R&D and pre-competitive investment and coordination and support has a strong element at a European level in the EU Framework programmes, especially in mobile communications. Finally, standardisation has a strong centralised element in telecommunications, primarily (although not exclusively) through ETSI, which took over GSM standardisation in 1988, and continues to exercise influence on 3G and 4G standardisation are a founding partner of 3GPP.

The partial harmonisation approach is visible in the European 3G licensing process which occurred at the turn of the century. European governments specified the UMTS standard in the award of licences. However each country was free to offer licences in any way. The number of licences awarded (via beauty contest, auction etc) depended on a calculation of the number of operators needed to create a competitive market, expected and the required level of investment needed to actually build those networks. In some cases those awarded licences handed them back, unable to afford to build the network (due to the high cost of licences and the 2000 stock market crash). Subsequently some countries have decided to offer more licences for new infrastructure, while others have insisted on opening wholesale markets in mobile capacity to increase competition. The mobile market in the 2000s was also characterised by take-overs, particularly, cross-border, corporate failure and consolidation as firms struggle to compete in markets with 4 or 5 operators.

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[5] E.g. Council Resolution of 7 May 1985 on a new approach to technical harmonization and standards [Council Resolution (85/C 136/01) - Official Journal C 136 of 4 June 1985]

[6] Commissioner Reding (InfoSoc), 2007, Towards a True Internal Market for Europe's Telecom Industry and Consumers – the Regulatory Challenges Ahead, Speech to 20th Plenary Meeting of the European Regulators Group Brussels, 15 February 2007

This report will detail general features of standardisation in Mobile telecommunications, summarising a more extensive description in D3.

1.2. Standards making process in mobile telecommunications

The ITU is the formal UN body representing nation-states responsible for specifying and selecting and 3G and 4G mobile standards. Within ITU(R),Working Party (WP) D of SG 5 ('Terrestrial Services') is in charge of IMT Systems[7] including IMT Advanced, ITU's 4G initiative. However, initial technical specifications and development work is done outside ITU and submitted for evaluation by ITU-R membership, standards organisations, and other organizations who apply to be evaluators.

While 3GPP2 and IEEE have been important standards bodies in wireless communications standards development, the principal standards setting or developing body[8] in 3G and 4G mobile is the 3rd Generation Partnership Project (3GPP), the inheritor of GSM process run by the European Telecommunications Standards Institute (ETSI), and source of the most commercially successful 3G family of standards[9]. The 3GPP is a collaboration agreement that was established in December 1998. The agreement brings together a number of telecommunications standards bodies, essentially the leading SSO from China, the USA, Japan, the EU and Korea[10]. The scope of 3GPP is to produce, and maintain, globally applicable Technical Specifications and Technical Reports for a 3G mobile system based on GSM core networks.

The current project is 3GPP LTE (Long Term Evolution). It is expected that Version 10 will meet IMT Advanced criteria. Partners in 3GPP are classified as either 'Organizational Partners' (OP) or 'Market Representation Partners'. The former category is open to any SDO with the capability and authority to set standards in a specific nation or region, and an IPR policy compatible with those of the other OPs. Also, all OPs need to commit themselves to the 3GPP scope, and to sign the Partnership Project Agreement. The 'Organizational Partners' determine the general policy and strategy of 3GPP, and convert the general specifications into local specifications. Market Representation Partnership is open to organisations that are not SDOs but have the capability to contribute a consensus view of relevant market These include intermediary organisations and industry alliances that play a coordinating role such as the UMTS Forum, Global GSM Association UMTS TDD Alliance, TD SCDMA Industry Alliance TD-SCDMA Forum and 3G Americas.

In addition, an organisation that is a member of an OP may apply for Individual Membership. By June 2008 337 organisations have successfully done

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[7] IMT is an acronym for *International Mobile Telecommunications*

[8] Standard Setting Organisation (SSO) or Standards Developing Organisation (SDO) tends to be use for formal bodies, while Standards Developing Body (SDB) covers both the 'formal' or accredited bodies (like e.g., ITU-T, ETSI, or IEEE) and standards consortia (like WorldDMB). (Deliverable 3)

[9] http://www.3gpp.org/

[10] ARIB (Association of Radio Industries and Businesses; Japan) ;ATIS (Alliance for Telecommunications Industry solutions; US) ; CCSA (China Communications Standards Association; China) ; ETSI (European Telecommunications Standards Institute; EU) ; TTA (Telecommunication Technology Association; Korea) ;TTC (Telecommunication Technology Committee; Japan)

so. 24 of them are members through the OP ATIS, 14 through CCSA, and 156 through ETSI. Companies are often members though two organisations, for example Huawei is a member via different memberships of ETSI, CCSA and ATIS. Decision making at PCG level is based on consensus; voting should only be necessary only if exceptional cases. 71% of votes in favour are required for a proposal to be approved. The actual technical specification work is performed by four 'Technical Specification Groups'. Each Individual Member (i.e., companies) need to obey the IPR Policy of its OP, and should declare at the earliest opportunity, any IPR they believe to be (potentially) essential. OPs, in turn, should encourage their respective members to grant licenses on fair, reasonable terms and conditions and on a non-discriminatory basis (FRAND). 3GPP does not contribute directly to the ITU. Formal contributions to ITU Study Groups are made by Individual Members who are also members of the ITU.

The central position on 3GPP however should not mask the work of a large number of other organisations that are developing standards in the mobile arena, such as the Open Handset alliance, IEEE, other ITU Study groups, Internet standards organisations etc (Figure 1).

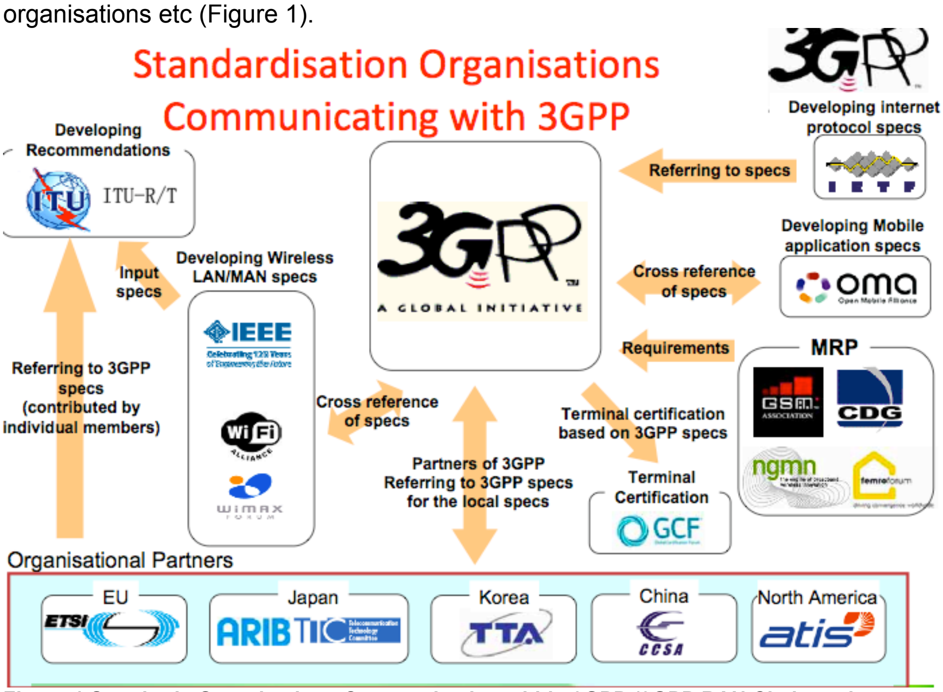

Figure 1 Standards Organisations Communicating within 3GPP (3GPP RAN Chairman's presentation to the ITU-R WP 5D Third Workshop on IMT-Advanced 15 Oct 2009)

2. From 3G to 4G mobile systems

Third Generation (3G) mobile systems were developed at the end of the 1990s, using a range of market predictions and technologies available at the time, and emerging from contemporary regulatory conditions, industry relations and government policy[11]. The limitations of previous second generation systems such as GSM, in terms of flexibility and capacity and the opportunity to advance the capability of infrastructures were obvious technical factors encouraging innovation. A key driving player was Japan, which had ‘run out’ of 2G capacity and were keen to drive forward a new generation of mobile technology in new spectrum bands. However the development of Third Generation mobile systems led not to a unification of standards, but the fragmentation of existing mobile systems into a range of different standards and implementations. The success of the European led 3GPP consortium standards has created a *de facto* dominant set of global standards. Currently attempts to specify, develop and standardise ‘fourth generation’ mobile systems are well underway.

[11] The European 3G system was developed initial from 1998-1995 in European Commission sponsored research programmes (RACE). The subsequent battles of industrial consortia was resolved through ETSI in 1998, and combined with the Japanese proposal to produce the most successful standard, UMTS

Glossary of Wireless Communications Methods relevant to understanding 3G and 4G mobile systems

Duplex Method

This is the means by which the spectrum is used to allow 2-way communication between two transceivers. Relevant, as the choice relates to how much spectrum is needed to offer a service.
FDD Frequency Division Duplex. The receiver and transmitter use different frequencies. In mobile systems paired spectrum bands are allocated to operators, one for the uplink, the other for the down link.
TTD Time Division Duplex. A single spectrum band is used, receiver and transmitter signals are send in different time slots. Advantages include being to dynamically alter the proportions of spectrum used for transmission and reception, such as web browsing when much more data is downloaded than uploaded over the link. However it depends on time-division multiplexing technology to ensure accurate timing in transmitter and receiver. (e.g. Dahlman, Ekström et al. 2005)

Multiple access method (multiplex)

These allow multiple mobile devices to communicate with the base station in a shared spectrum band. Mobile communications generally use the following circuit switched methods. Each has its own benefits and shortcomings such as power use, timing difficulties, susceptibility to interference, and can be combined to create improved methods.
FDMA: Frequency Division Multiple Access. Each device allocated a frequency for the duration of the call
TDMA: Time Division Multiple Access: multiple devices take turns to transmit over same frequency band
CDMA: (Asynchronous) Code Division Multiple Access: A sophisticated method that encodes each transmitters signal and transmits it on the whole allocated spectrum band (spread spectrum). Signals are much less prone to interference than previous methods, and spectrum can be used more efficiently in 'bursty' use typical of telephone calls.
Synchronous CDMA – a version of CDMA requiring precise synchronised timing of transmission from all (mobile) transmitting devices.

Access Methods used in 3G

These are the names given to describe the access methods specified in 3G standards
W-CDMA: Wideband Code Division Multiple Access. An implementation of CDMA. Used in a FD duplex mode, know as UTRA and used in the European/Japanese *UMTS* 3G system.
TD-CDMA: Time-division CDMA: Combination of Time division duplex and code division multiplex techniques.
TD-SCMA: Time Division Synchronous Code Division Multiple Access. An application of Synchronous CDMA used in a TD duplex mode. The 'Chinese' 3G standard. (Kammerlander, 2000)
These latter two methods make up the UMT-TDD or IMT2000-TD air interface standard.
Cdma2000 – the brand name given to an implementation of CDMA techniques in Qualcomm's 3G standard
Orthogonal frequency-division (OFDM). OFDM is a robust digital multi-carrier modulation technique used in a wide range of data transmission systems, both wired and wireless, such as LTE, DVB, WiFi, ADSL, WiMax etc (see for example http://www.supelec.fr/d2ri/flexibleradio/cours/ofdmtutorial.pdf)
OFDMA: Orthogonal Frequency Division Multiple Access is the multiplexed used of a sophisticated vision of TDMA known as The basis of the downlink of the LTE 4G wireless access system known as Evolved UMTS Terrestrial Radio Access (E-UTRA). Can be used in TD and FD duplex modes.

The ITU had originally promoted the concept of a unified set of standards in its IMT 2000 process, which failed for commercial competitive reasons, resulting in 2 main 3G standards sets: Universal Mobile Telecommunications System (UMTS), developed by 3GPP building on the European GSM system, and CDMA-2000 Evolution-Data Optimized (EVDO) standardised by the US-based 3GPP2 consortium, based on the CDMA 2G system. However, both these standards aimed to meet the criteria for a 'third generation' mobile system, introducing packet switching and non-voice services[12]. Despite many early problems with implementation, 3G networks have been rolled out successfully around the world. Neither of these sets of standards are static: there have been considerable evolution in both; for example by 2008 the 3GPP standards had reached Version 8, embracing a considerable range of new technologies and functionality not found in the original

[12] Although 1x EV-DO is often considered a 2.5G standard.

specification, pursuing aims of increased bandwidth for end users to have mobile broadband access, and reduced costs of network ownership and upgrade for the operators.

With respect to the wireless technologies used in 3G systems, there is considerable scope for operators to select different radio interfaces, which may be taken as a euphemism for the fragmentation of specification. At the moment there are 6 official radio standards in IMT 2000, and the legacy systems (e.g. GERAN from GSM). 3G radio interfaces include those specified in UMTS Terrestrial Radio Access, UTRA[13], (W-CDMA, TD-CDMA and Chinese TD-SCDMA[14]) from 3GPP, and CDMA 2000 (1xRTT and 1xEV-DO) from 3GPP2[15]. This fragmentation is the remains of earlier compromise and failure to compromise. For example, W-CDMA and TD-CDMA are two remaining specifications of seven originally proposed in 3GPP, representing the proposals of two consortia, respectively Nokia and Ericsson developing for NTT DoCoMo, and one proposed by Alcatel, Siemens and Motorola (Bekkers and Liotard 1999). While in the specification, TD-CDMA was not implemented except in the subsequent Chinese-led development, TD-SCDMA.

Both 3GPP and 3GPP2 bodies have developed higher bit rate radio interfaces as extensions of existing interfaces, such as the UMTS HSDPA[16] , often referred to as 3.5G and marketed as mobile internet for portable computers. Currently many operators are implementing technologies based on these specifications.

Actual implementation of 3G standards currently occurs about 4 years after publishing – for example HSDPA technologies standardised in Release 5 of 3GPP standards in 2002 were implemented in 2006; HSPA+, standardised in 2007 was currently in early trials in 2009. However standards-making processes are speeding up, especially in 3GPP as the organisation reaches maturity, and implementation seems to be following faster too.

2.1. Beyond 3G

Ever since the development of the initial 3G standards, there has been considerable work on the technical, business and regulatory factors to create new systems 'Beyond 3G' (B3G)[17]. Some of this work has been incremental developments of 3G,

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[13] In GSM/UMTS terminology the Radio Access Network is refers to the systems between the core network and the handsets, which includes the radio interface technology, the base stations and their interfaces with the core network. The UTRAN system can incorporate a range of radio interfaces.

[14] In 3GPP standards 'TD-SCDMA' is formally 3GPP TDD 1.28 Mcps LCR option, Together with TD-CDMA they are know as UMTS-TDD, or IMT2000-TD

[15] Another recent addition to the 3G radio interface family is the IEEE 802.16: Broadband Wireless MAN Standard (WiMAX) , produced in the IEEE standardisation processes and promoted by the industry association WiMax forum. While originally not a mobile wireless technology, it is evolving into a potential competitive alternative to the other standards, although much of the Radio Access Network apart from the radio interface is not yet defined.

[16] HSDPA - High Speed Download Packet Access is part of the High-Speed Packet Access (HSPA) a development of the radio interface in 3GPP standards to allow fast data access. It is relatively easy to upgrade existing 3g systems to this standard. First standardised in Release 5 in 2002, implemented from 2006 by over 200 operators, and marketed as mobile broadband. HSUPA started to be implemented in 2007. HSPA Evolved (HSPA+) was included in Release 7 (2007), and in currently in trials in various networks. This is the last development of the original 3GPP 3G standard before LTE which uses a new air interface.

[17] See for example (ITU 2003b)

Proposed Features of IMT Advanced

- a high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost efficient manner;
- compatibility of services within IMT and with fixed networks;
- capability of interworking with other radio access systems;
- high quality mobile services;
- user equipment suitable for worldwide use;
- user-friendly applications, services and equipment;
- worldwide roaming capability; and,
- enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for research)

(From ITU Radiocommunication Study Groups, Working Party 5D Background on IMT-Advanced, Document IMT-ADV/1-E, 7 March 2008)

other work is more radical, suggesting that completely alternative infrastructures from wireless communication, such as decentralised peer-to-peer radio, or open spectrum solutions.

As well as an incremental development of 3G systems outlined earlier, there is also a need to define a whole new specification for a new generation of managed mobile network systems, with developments in both radio and network technology . These will finally move from a hybrid system linked strongly to 2G technologies towards core networks that are all Internet Protocol-based, and radio systems that can deliver much greater flexibility, data rates and user density than currently available, as well as compatibility with existing generations of mobile systems. Unlike the initial 3G systems, which were still wedded to a voice-centred view of telephony, the new systems are often termed *mobile broadband* rather than mobile telephony.

This exact conception of what 4G might be has of course been the subject of considerable debate and commercial positioning since at least 2004. However, the ITU and the main standards development bodies are eventually agreeing of a set of outline specifications for what a 4G system should be capable to delivering for implementation after 2010, probably around 2015.

To this end the ITU[18] initiated a process called IMT Advanced, to outline the specifications of a 4G mobile system and invite submissions of candidate Radio Interface Technologies (RIT)[19]. Rather than attempting to assess and closely define standards, the IMT Advanced process attempts instead to " ensure that IMT-Advanced technologies are able to fulfil the objectives of IMT-Advanced and to set a specific level of performance that each proposed technology need to achieve in order to be accepted within ITU-R for IMT-Advanced" [20],[21].

A crucial part of the process has been to identify the radio spectrum issues involved in 4G, in particular to open up new spectrum bands, change the regulation on use of

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[18] Working Party D of SG 5 of ITU-R is in charge of IMT Systems.
[19] See for example (ITU 2008b)
[20] Requirements, evaluation criteria and submission templates for the development of IMT-Advanced, Doc. 5D/TEMP/78(Rev.1) Attachment 7.2 p.2
[21] ITU (2007) Resolution ITU-R 57, "Principles for the process of development of IMT-Advanced".

existing bands, and attempt to development a degree of international harmonisation. Much of this work was done at the 'Spectrum Olympics', the ITU World Radio communication Conference 2007 (WRC-07)[22]. This conference of regulatory authorities governing radio spectrum covers all radio spectrum, and is primarily concerned with managing interference, developing policy and allocating common spectrum bands for new services.

While new '4G' radio interfaces are an important part of this new standardisation process, another very important aspect is integration of Wide Area Mobile WAN) systems with other wireless and non-wireless systems – local area and body area networks for example. The European Commission has been a strong promoter of this conception of Beyond 3G. For the operators too, there are broader issues than just a new mobile system: many telecoms companies are integrating fixed, mobile, internet and broadcasting services and business units, and investing in all-IP backbone 'Next Generation Networks' (NGNs). It is therefore equally important that new systems integrate seamlessly with a wider set of telecommunications systems and services.

2.2. 4G standardisation

The three proposed sets of standards that are emerging as serious 4G candidates are the IEEE standardised Mobile WiMax (which includes Korean WiBro system), 3GPP LTE-Advanced (Long Term Evolution) and 3GPP2 UBM (Ultra Mobile Broadband). While they have their differences, these systems all take advantage of a range of new technologies, such as MIMO[23], beam forming, and OFDM[24] radio. Of relevance to this case are the Chinese government agencies, who are participants in all of these standards-making processes, most notably the CCSA (China Communications Standards Association) Wireless Communication Technology Committees. Working Group 6 of this committee is the responsible for Beyond 3G. The standardisation body most relevant to this study is the 3GPP, since the Chinese TD-SCDMA is one of the air interfaces standardised within their processes, Perhaps more importantly, network upgrade announcements in 2008-2009 suggest that mobile operators are overwhelmingly opting for 3GPP standards path.

The 3GPP programme for mobile broadband communications is termed 'Long Term Evolution" (LTE). This supposedly provide a 'smooth evolutionary path for operators deploying all 3GPP and non-3GPP technologies' (UMTS Forum 2008). While the medium term aim of the programme includes meeting '4G' criteria with LTE-Advanced, LTE is a major development of technologies aimed at meeting the needs of operators in the next 4-5 years. Leaving behind the establish WCDMA radio, LTE includes an entirely new radio interface specification, known as Enhanced-UTRA that is not compatible WCDMA interface. It will support both FDD and TDD modes (See Glossary). The proposed new core network is referred to as Evolved Packet Core (EPC) and is intended to make it easier to integrate 3GPP systems more easily

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[22] http://www.itu.int/ITU-R/index.asp?category=conferences&rlink=wrc-07&lang=en
[23] MIMO – Multiple Input Multiple Output – a range of techniques using multiple antennas in the base station and handset to increase range, reliability or net spectral efficiency.
[24] OFDM : Orthogonal frequency-division multiplexing, a robust digital multi-carrier modulation technique used in a wide range of data transmission systems, both wired and wireless, such as LTE, DVB, WiFi, ADSL, WiMax etc (see for example http://www.supelec.fr/d2ri/flexibleradio/cours/ofdmtutorial.pdf

with non-wireless and non 3GPP systems: i.e. it aims to offer operators more flexibility. LTE was fixed in 3GPP Release 8 during 2009, with developments in Release 9 projected for the end of 2009. Trials of LTE have been run over the last 2 years a number of firm orders have been placed by operators to be implemented by 2012, although widespread adoption depends on economic conditions.

While the work of standardisation for 4G is headlined by the ITU and the IEEE, 3GPP and 3GPP2 there are many other intermediary organisations that are playing important roles. For example, the Next Generation Mobile Networks organisation[25], represents Telecoms Operators in the process, while research networks such as emobility [26] link in majors vendors with smaller firms and universities to develop technologies and set agendas for EC research funding. Other bodies such as the UMTS Forum[27] and TD Forum 'provide marketing input to technical standardisation bodies' (UMTS Forum Scope Statement). These are just a few of the institutional members of the mobile telephony/broadband ecosystem[28]

Of course, this development and standardisation process depends on there being a final market, that operators will adopt the infrastructures, and their customers will buy the services that can offer. One objection to the whole 4G process is the 'customers are not ready for 4G services'. This is however mistaken: first, a large part of the technical innovation is aimed at creating infrastructures that are more efficient and flexible for the *operators*. Secondly, there is already considerable investment in 3.5G infrastructures in many countries as they enable current demand to be satisfied, demand which is focused on data and Internet usage as much as mobile (operators would like to sell each customer a data modem service as well as a telephone handset based service). Finally, unlike the period when 3G was implemented in Europe, end users now have devices such as smart handsets that can actually make use of the broadband Internet facilities of 3.5 and 4G mobile systems.

However, there are important issues of timescale: when will operators be prepared to actually invest in a major new system, and what will it take for them to trust that it will pay back, and work, given the history of 3G? 4G also raises the issue of 'leapfrogging'. Maybe it is better for operators to wait for newer technologies than invest in today's 3G systems? As far as standards are concerned, it is clearly in the operator's interests to invest in systems that are interoperable to their current infrastructures to enable an evolutionary rather than step change. For regulators, there are questions of promoting competition v. standards harmonisation, the release of new spectrum bands and the terms under which they should be offered[29], and the specification of technologies that should be used in those bands. Finally, there is a question of national industry policy, and the support for national champions and

[25] NGMN (http://www.ngmn.org) set up in 2006 by 19 operators including China Mobile, and sponsored by many vendors including Chinese firms Datang and ZTE. One of their aims is to speed up standardisation, and make sure the IPR regime of the standards is favourable for operators (Molin 200)
[26] http://www.emobility.eu.org/
[27] UMTS forum has a mixture of government, vendor, operator and research organisations as members http://www.umts-forum.org/
[28] A more complete list can be found in Deliverable 3
[29] Following the lucrative but eventually commercially disastrous auctions of 3G licences in some European countries.

indigenous technology capabilities[30]. The proponents of LTE and LTE Advanced suggest that the design of these systems, which allow to much greater inter-operability, backward compatability and simpler upgrade, make this less of a issue than with previous step changes in technology. The global economic crisis is certainly slowing investment too. Vodafone, for example, is focusing on consolidating its HSDPA (3.5G) investments for the foreseeable future[31], and China Mobile is likely to concentrate on the rapid roll-out of its first TD-SDCMA network. Nonetheless, the Norway-based operator, Telenor, has made firm orders for LTE systems from Huawei for its domestic market.

2.3. Intellectual Property in Mobile Telecommunications

Intellectual Property is a key issue in telecommunications standards[32], extensively discussed in the literature (e.g. , Bekkers, Verspagen, et al. (2002), Iversen, E. (2000)) and is intimately linked to the story of 3G. Most mobile systems include IPR[33] protected technologies from a number of firms. The development of a standard involves the negotiation of agreements between IPR holders over how and if they will be compensated for IP included in the specification. The strategies followed by firms in this process can impact significantly on competitive position and market outcomes. Briefly, in the GSM system, the major companies participating all brought IPR, and a largely followed a gentleman's agreement with pooling of rights. The IPR rules were set largely by European telecoms authorities. Each vendor was able to sell GSM systems that included other's technology. However Motorola held considerable patents and insisted on patent cross-licensing, which only a few competing firms agreed to. This led to a small consortia of firms (Ericsson, Nokia, Siemens, Motorola and Alcatel) controlling 85% of world GSM market by the end of 1990 (Bekkers and Verspagen 2002), effectively locking out all the firms, including Chinese vendors, who did not hold enough IPR to enter into cross-licensing agreements, and were therefore obliged to pay full licensing costs[34]
A similar process occurred with 3G, by which time many vendors were increasingly conscious of the need to patent, and develop IPR strategy. For example, one of the leading innovators patent holders in mobile telecoms is the US firm Qualcomm, who hold many of the historic and recent CDMA patents[35]. CDMA technology is used in the early 2G digital mobile system widely deployed in the US, and in a number of other countries, including China. Qualcomm are a firm that relies heavily on licensing income, and defends it right to charge for IPR vigorously. One of the main factors in the split of 3G standards processes into 2 consortia, 3GPP and 3GPP2 was over the licensing agreements. Vendors of equipment using the 3GPP2 standard, CDMA2000, pay royalties direct to Qualcomm. 3GPP standards operate with a

[30] (Funk 1998) and (Funk and Methe, 2001) suggest that in previous generations of mobile telephony the most successful firms have been those that had a government that created a protected domestic market that that they could exploit before launching onto the international stage.
[31] REF
[32] The more general relationship between innovation, IPR and Standards is covered in Deliverable D3, of this project Review of State of the Art, Section 3 p.14.
[33] IRP includes both patents and copyright, which applied to software in some jurisdictions.
[34] Bekkers and Liotard (1999) suggest up to $50 per $150 handset at that time.
[35] The other major CDMA patent holder is Ericsson.

patent pooling system, where all vendors pay into the pool for the right to use IPR in the 3G standard. In the case of 3GPP's UMTS system, vendors are obliged to pay into the pool *and* to pay Qualcomm for rights associated with CDMA technology. Firms those technology is included in a standard, making it therefore 'essential', are obliged to offer this on 'Fair, Reasonable and Non Discriminatory terms' (FRAND) set within the SSO (Treacy and Lawrance 2007). Firms who are members of 3GPP through the European SSO, ETSI are expected to use FRAND terms developed by the European Commission and ETSI[36]. This of course can lead to quite acrimonious debate over 'reasonable' value calculation in setting price, in this case leading to a number of court cases and anti-monopoly investigations against Qualcomm in the US and EU, a range of other disputes, and ongoing policy development on the workability of FRAND (Treacy and Lawrance 2007). WCDMA licensing agreements are still not fully resolved, where uncertainty over future IPR claims is cited as a factor hindering the development of 3G market, particularly in low-cost markets[37].

A third standard that would reduce the fees paid by vendors would therefore by a very attractive proposition, especially for firms with little IPR in existing standards who neither benefit from direct or indirect income, and were in a weak position in entering into bilateral cross-licensing agreements to use other firms IPR[38] - we recall how many firms were locked out of the GSM standard, and in 3G, the success of W-CDMA over TD-CDMA disadvantaged firms with IPR in the latter. For this reason, China's proposition is of interest not only to Chinese firms, but also to many other firms wishing to sell mobile telecommunications equipment. However, the TD-CDMA standard is hardly independent of historical patents in CDMA. It is not easy however to confirm exactly who owns what in TD-SCMA. A document posted on the TD-SCDMA forum website in Jan 2006[39] states:

> "Most of the 3G-related patents are in the hands of over 30 foreign companies, except Huawei and Datang Telecom have 5 percent of WCDMA-related basic patents and 7.3 percent of TD- SCDMA-related basic patents respectively." "ZTE has considerable basic patents in WCDMA, CDMA2000, and TD-SCDMA" "There is no latest statistics on the basic TD- SCDMA patent owners. There was some statistics showing that Nokia owns 32 percent of the patent rights, Ericsson 23 percent, Siemens 11 percent, Datang Telecom 7.3 percent, and Qualcomm 2 percent.".

However other interviewed sources suggest that Chinese firms have higher percentage of IPR in TD-SCDMA, but it is unclear what percentage is being measured. TD-SCDMA clearly relies on historical CDMA patents, some of the largest patent holders being Qualcomm and Ericsson, both members of the TD-SCDMA Forum.

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[36] Chinese firms who are only members through CCSA can use terms set by the CCSA.

[37] Vincent (2007) Low Cost 3G Devices, How Can We Achieve the Balance in IPR Needed to Afford 3G for All?, 3glicensing http://www.3glicensing.com/articles/News%20LowCost.pdf and Osamu Nakamura and Christopher Martin Kerr (2008) Current Status of Platform 2008 WCDMA and its Joint Patent Licensing", NTT DOCOMO, http://www.3glicensing.com/articles/DOCOMOTechnicalJournal_vol10no3.pdf

[38] E.g. Nokia, Huawei sign patent licensing pact 2008-10-14 "Nokia and Nokia Siemens Networks … reached a licensing agreement on standard basic patents, which covers the right of use of all standard basic patents in global market, including GSM, WCDMA, CDMA2000, optical fibre network and WiMAX (Official Chinese IPR website http://www.chinaipr.gov.cn/news/headlines/245674.shtml)

[39] http://www.tdscdma-forum.org/EN/news/see.asp?id=2567 Cited with source sinocast. Access Nov 2009

Chinese firms have negotiated special terms in then the payment of IPR fees for mobile technology in both 2G and 3G system. especially in relation to Qualcomm. Huawei for example pays 1% licence fee to Qualcomm for domestic 3G sales (CDMA2000 and WCDMA) and 6-7% for exports[40]. With TD-SCDMA becoming a commercial product firms such as Qualcomm are making agreements to licence its IRP to firms supplying TD equipment.

3. Telecommunications in China

3.1. Background: Institutional Change

Telecommunications are 'pillar' industries in all countries, and of vital national security interest, and China is no different. There is a wide range of literature on the development of telecommunications in China, but the last 10-12 years is generally identified as arguably being the most turbulent, and involves changes that go to the heart of the Chinese political and industrial system. Analysis of the development of a mobile telecoms standard therefore requires foremost an understanding of the larger political-market context, more than a focus on the detailed standard-making procedures of standards setting organisations (SSOs). The key feature is the difficult introduction of market reforms to large strategic state owned enterprises and infrastructures regarded as 'commanding heights' or 'economic lifeline' (jingji mingmai) of the national economy (Pearson, 2005). In the 1990s it was clear that these large state enterprises were highly inefficient, but unlike smaller and less important industries, change was hard to initiate. Nonetheless, reform[41], in the form of pseudo-liberalisation, creating a competitive environment for incumbent state-owned firms, was necessary in order to improve economic efficiency and stimulate innovation. 5-year plans since 1986 emphasise the importance of high technology R&D and innovation by commercial industry figures prominently in the 11th Plan of 2006 (Ure 2007).

According to the analysis of Pearson (2005) the opening up of the Chinese economy involves essentially, the separation of industry and government (zhengqi fenkai), a process first initiated in 1994, and reattempted at various points since then (Gao and Lyytenin 2000) . This has taken three forms: the 'streamlining' of bureaucracy, the establishment of regulatory agencies and the spinning off of state owned enterprise (Pearson 2005). However the introduction of competitive, regulated markets has been shaped, and some would say highly constrained by continued state ownership of key economic asset, the dominance of state and party institutions, and fragmented regulators[42] with poor separation from government ministries (Pearson 2005). This has left China somewhere between a fully deregulated market with independent regulators and the developmental state model characteristic of Japan's period of post-war growth, attempting to fulfil development

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Comment: it was never for liberalisation; rather it was for creating a competitive environment for incumbent state-owned firms

[40] Source: Chinese 3G Equipment Providers in Talks on IP Issues 2006-1-20, TDSCDMA Forum
[41] Chinese economic reform started in 1978, and since then has attempted to develop a market economy and maintain socialism (Gao and Lytytinen, 2000)
[42] This is not a Chinese phenomenon : in the 1990s fragmentation was concerning telecommunications scholars in the US and EU (Lehr, and Kiessling 1999) and in 2009 in the US, the home of the liberal market, fragmentation of regulators was cited by a government report as the cause of the global financial crisis (GAO, 2009)

goals through ‘orderly competition’, with continual political ‘interference’ divided objectives and institutions.

A key moment in forcing this process was accession to the WTO in 2001, and the adoption of a timetable for liberalisation during the 2000s, including the opening of markets in goods and services to foreign firms, opening to foreign investment, the creation of regulated markets, requiring anti-monopoly law (Li, 2008), intellectual property law, the introduction of consumer protection, and the development of more transparency. The accession process had lasted many years, in often acrimonious negotiation with the USA (Nakatsuji, 2001), the resolution of which specifically included deals of mobile standards. Much of the analysis of the mobile telecommunications market has been made within the context of the post-WTO liberalisation.

While creating and opening national markets brings many benefits, including foreign investment, knowledge transfer and access to global markets it also upsets ‘orderly’ development and exposes strategic domestic industry to more efficient foreign competition. Industry policy, theoretically (if not in practice) attempts to maximise the advantages and minimise the disadvantages. However policy also attempts to strengthen the ability of national industry to compete globally, not just on items low on the value chain, but also with high value innovation in order to increase competitive advantage (Ure 2007). Technology policy, and in particular standards policy can be interpreted from this perspective. This development of this policy, and the tendency to ‘technonationalism’ or ‘technoglobalism’ globalism in Reich’s terminology (Reich 1987, quoted in Lee, Chan & Oh 2009) which is perhaps most clearly demonstrated in telecommunications, is discussed in the next section.

3.2. The creation of telecommunications markets in China

This analysis draws on a number of sources, especially Pearson (2005), Gao and Lyytinen (2000), Li (2008, 2009), Ure (2007), Reimers and Li (2007) and (Lee, Chan & Oh 2009) as well as research interviews and contributions by members of the project team. The development of the telecommunications market is the story of the development of two markets, one in equipment to build the infrastructure and for end users and one in services that infrastructure can be used to provide. The use of markets to develop infrastructure and provide services is relatively new, and is an ongoing story in all countries, and indeed global, in the case of equipment, and to a much lesser extend in services.

The Chinese telecommunications sector was regarded as quasi-militarised and one of the most monopolistic industries (Shen, 1999). The Ministry of Posts and Telecommunications was established right after the foundation of the PRC in November 1949. From then to 1978, the government was the sole investor in telecommunications networks and services. Because of its utter importance for political and security communications in the country, during the Cultural Revolution, the ‘telecommunications’ sector was separated from the ‘posts’ and in direct command of the People’s Liberation Army. The MPT was re-established in 1973, a programme to re-strengthen the sector started even before the economic reform in 1979. Equipment manufacturing capacity was built during this period. Soon after the initiation of the economic reforms, the MPT reshuffled the management of organisations and put its 28 manufacturing firms under the Posts and

Telecommunications Industrial Corporation (PTIC), its industrial arm newly established in 1980. Together with the direct control of the Directorate-General Telecommunications[43], the operator and as well as the regulator of the telecommunications network services, the MPT retained firmly the power over the entire telecommunications industry (Shen, 1999).

It was the opening up of the Chinese market that eventually weakened MPT's monopoly control. The Chinese government came under enormous pressure from the increasing demands of the domestic market and state financial shortages, as well as from foreign governments to open the Chinese telecommunication equipment market. The "walking on two legs" policy reflecting in the practices were to draw technological and financial resources from domestic sources, as well as from foreign ones. For that, the MPT had to decentralise its power and to allow local Posts and Telecommunications Administrations to muster funds from foreign soft loans, local governments and the customers, in order to expand its telecommunication service capacity (Shen, 1999). However, the decentralisation was carried out in a stringently restrictive manner, e.g. for any equipments to enter the telecommunication network, the fee level charged for using services, etc. required the central approval, except for the installation fees for telephone lines. The equipment market was also opened to a limited number of foreign players.

The outcome of these measures was extremely successful in terms of access to telephony services. In 1978 when China had merely 3,972,000 telephone lines compared to a population of over 900 million, with about 4 phones per 1,000 people. At the end of 2001, the number of fixed-line telephone subscribers increased to 180,390,000, the second largest in the world (Shen, 1999). The 1990s saw China's telecommunication sector experiencing the fastest growth rate (around 40-50%) in the whole economy and attracting the central attention from foreign as well as domestic players. With the fast development of the electronics Industry in parallel with the telecommunications, the Ministry of Electronics Industry (MEI) regained status. In 1992 , in response to long discrimination by the MPT towards products of the MEI being used in public telecommunications network, the MEI together with the Ministry of Railways and Ministry of Electronic Power proposed the establishment of United Telecommunication Co (Unicom) to run a second telecommunication network. This proposal was approved by the State Council in December 1993 (Tan, 1994 and 1999, Gao, Lyytinen 2000)[44]. This move signified the new measures adopted by the central government to create an competitive environment for a limited number of state-owned players to compete and therefore to achieve further growth and efficiency in the telecommunications sector. At its founding, the company was granted a spectrum[45] to build new wireless network. Compared to the Unicom, the then MPT's GSM cellular network had only 4 MHz bandwidth (Howit, 2008). In the same spirit, China Telecom, a service operator of the public telecommunications network was established in 1995, which was to separate the business operation from the regulator role MPT was left to play. The mobile industry grew out of such a political and economic environment.

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[43] The former body of China Telecom.
[44] Unicom had these three ministries at the core and was joined by 12 other partners when officially launched in July 1994
[45] 6 megahertz in the 900 MHz spectrum.

Following the worldwide wave of building 'national information superhighways' initiated by the US in 1993, China's State Council created the Steering Committee for National Information Infrastructure in 1996 (Tan 1999) to handle the new emergent Internet related matters, including not only the information infrastructures but also Internet services that is highly politically and security sensitive. Many interested agencies of government were involved in the process of telecoms and information technology reform, including the Communist Party's 'informatisation leading small group', the National Sate and Reform Commission (NDRC)[46], and the People's Liberation Army. The NDRC is part of the State Council, and is responsible for all major decisions of government investment, including major restructuring and since 2003, oversight of industry policy (Pearson 2005). The outcome of the negotiation between various ministerial bodies was the merger of the MPT and MEI to form the Ministry of Information Industry (MII) in 1998. However there was still no formal 'Telecommunications Law' to ensure clear the definition of a market and policy goals and put China Telecom and China Unicom on equal footing (Gao, Lyytinen 2000). 1998 is a significant date in the chronology of 3G standards development, as in Jan 1998 a Chinese 3G standard was proposed internally, and in June 2008 submitted to the ITU. It is also the year that all EU Members States were also formally obliged to create independent regulators.

The newly formed MII subsequently undertook 2 major reorganisations in 2000 and 2002 of the telecommunications infrastructure, breaking up China Telecom, and forming 6 multifunctional firms, with China Telecom split into a Northern and Southern parts. China Mobile was split from China Telecom, and 'given' 50% of mobile market, and China Unicom given 25% (Li 2009). Commentators suggest that while these reforms were superficially about improving efficiency, they were actually mandated by the State Council as a way of easing inter-ministry tensions (Li, 2008). Rules issued in 1999 and 2000 state that the State Council has authority over basic regulation (Pearson 2005).

This arrangement remained in place, until 2008. China Mobile became a much stronger player (credited for example, to a youthful management), while China Unicom, saddled with 2 incompatible networks lost market share to around 25%. The year 2000 also saw the creation of a set of telecommunications regulations to govern services and interconnection (Li 2008) The next major reorganisation came in 2008 at the same moment as the introduction of Anti-Monopoly legislation (Li, 2008, 2009), and involved not only the reorganisation of the industry, but also the regulator/ministry. This seems like another attempt to resolve tensions and fragmentation. The new 'super-ministry', the Ministry of Industry and Information technology (MIIT) merged the MII, the Commission of Science and Technology (COSTIND) and some other agencies, including parts of the NDRC (Li 2009). On May 23 2008, the Ministry of Finance, MII and the NDRC issued jointly the Notice on Deepening Telecommunications Reform . The 6 operators were reorganised and reduced to 3 full service operators, in an apparent attempt to introduce more balanced competition in all services, and level the playing field for the issue of 3G licences. The remaining firms are China Telecom, China Mobile and China Unicom

[46] At this time the NDRC was called the State Development and Planning Commission (SDPC)

3.3. Mobile Telecommunications in China

The development of the Chinese mobile telecommunication market started in the 1980s with the first analogue mobile service (TACS) was built in 1987 in Guangdong Province[47]. In the same year, China Unicom started the development of a GSM network, followed by China Telecom in 1995. From this moment annual mobile subscriber increased at rates of more than 150%, with penetration levels high enough to make China the largest consumer of mobile telephone services in the world in 2003.

Apparently under political pressure resulting from an agreement reached with the U.S. in 1999 when the Premier Zhu Rongji visit the America, China Unicom started construction of a CDMA network in 2001. This was in commercial operation by Spring 2002. The first round CDMA network contained 15,150,000 subscribers while the second round doubled this number by Oct. 2002. In this period the CDMA network and China Mobile GSM network were upgraded to '2.5G'. At this stage China had 4 national mobile networks: China Mobile's GSM, China Unicom's GSM and CDMA, and the PHS (Xiaolingtong).

Undoubtedly China had achieved prominent success during a very short period in the market, but development of the infrastructure did not benefit national enterprises in the Telecommunication sector: operators did not purchase GSM or CDMA equipment from Chinese vendors. Various explanations have been given for this: national firms were not competent to deliver the equipment, they were obliged to pay high licence fees to the IPR owners since they could not enter into IPR cross-licensing agreements, and were thus unable to compete on price; and finally, the operators appeared not to trust or value the products of indigenous firms such as ZTE and Huawei. For example, these two firms won just 10% in the second round CDMA public bidding (Interviewed sources).

The development of the Chinese mobile telephone market was thus a coup for global telecom's vendors, whom are seen from the Chinese perspective as having made a very large amount of money from the Chinese market. Undoubtedly some of the weaker international players who invested heavily in China, such as Alcatel (in terms of IPR in GSM and 3G), may struggle without the Chinese market. During this period China was clearly the object of the industrial policy of the EU and the US, who both wished to promote the adoption of technologies and standards developed by their industrial champions in the world's largest market, and were willing to apply pressure and negotiate at a variety of levels to facilitate this.

By the end of the 1990s, a new generation of mobile telecommunications technologies were coming to market, and enterprises and governments would certainly fight hard to make sure they found a place in China.

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[47] Despite low initial take up, it reached 1,570,000 subscribers by 1994 .

4. The Chinese 3G standard - 'TD'

4.1. Development of an indigenous mobile phone system.

This section is provides the core empirical story of TD-SCDMA, and is drawn from interview sources, academic and trade literature, government communications and press coverage.

The initial idea of China developing it's own 3G mobile system was first promoted in the "Xiangshan Meeting" in Jan. 1998 . The Ministry of Post and Telecommunications (MPT) experts pointed out that China had "lost the 1G and missed the 2G" which made the Chinese 'enslaved' to 'western countries': China should therefore put forward it's own 3G standard to the ITU. Working with Siemens[48] the TD-SCDMA[49] system was developed by the Chinese Academy of Telecommunications Technology (CATT) , otherwise known as the Datang Technology Group. This standard was built on the 3GPP UTRA-TDD mode (see Glossary) initially championed by Siemens, but adopted much less widely than the FDD mode, WCDMA[50]. In June 1998, China formally proposed the TD-SCDMA blueprint to ITU. Eventually it was issued as one of the three international 3G Standards in May 2000 and accepted by the 3GPP in March 2001 as a result of the balance between the European-centred standard WCDMA and the U.S.-centred standard CDMA 2000.

From the beginning this technology did not have "real" political or economic support within China, for at that time TD-SCDMA was not seen as playing a role in "enhancing of China's economy strength and increasing of its GDP". Chinese media coverage was largely negative, with suggestions that TD-SCDMA was only hype., Together with the lobby of certain multinationals, TD-SCMDA faced a great deal of opposition. It was not a positive time for developing the new standard: the promoter, Datang, did not have resources for further research, and industry was not willing to make the investments necessary to turn a theoretical technology into a commericalisable product, in particular the investment necessary to produce the chip sets.

This situation did not change until Oct. 2002, Datang Mobile, Soutec, Holley, Huawei, Lenovo, ZTE, CEC and Potevio founded the TD-SCDMA Industry Alliance (TDIA)[51] . At the beginning of 2003, the first "TDIA Summit Meeting" was held, while the discussion was concentrated in some "practical" problems such as the share of the IPR, the further investment and the foreground of the market[52]. The TD-SCDMA

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[48] For a TD-SCDMA timeline from Siemens Perspective (http://www.td-tech.de/pr-art.htm (access 11/09/08)

[49] TD- SCDMA: Time Division Synchronous Code Division Multiple Access. All cellular radio access systems are a compromise of factors such as number of simultaneous users, ease of system implementation, the type of data traffic expected, mobility of terminals, range etc. TD-SCMA uses unpaired spectrum bands, since it mixes uplink and downlink traffic, in the same spectrum band, dividing them in timeslots (unlike FDD, which requires operators to have 2 paired spectrum bands). It cannot support as many users, and needs precise timing mechanisms in the terminal, but has lower range, but is easier to implement, For a biased evaluation see (Kammerlander, 2000)

[50] Known as TD-CDMA.

[51] http://www.tdscdma-alliance.org/

[52] The big mobile vendors (Nokia, Ericsson, Siemens, Qualcomm, Motorola and Alcatel-Lucent) between them hold 66% of TD-SCDMA IPR (IT Time Weekly, Issue 81, 5 June 2005 p.23

Alliance came to be an important body in the development of 'TD'. Datang's IPR was transferred to this body they, giving it responsibility for licensing, and it has also acted as the vehicle for government financing of TD development and commercialisation

Also in Oct. 2002, following the 2002 industry reorganisation, 155MHz frequency spectrum was authorized to TD-SCDMA by the Ministry of Information Industry (MII [2002], 479). Many scholars agreed that the 2002 was the first tipping point of TD-SCDMA's development since the foundation of the industry alliance and the allocation of frequency spectrum meant that the TD-SCDMA would have a place in the Chinese domestic market after all. After that, the attitudes of the press towards TD-SCDMA change, the most obvious difference was that they stopped playing up the technological disadvantages of TD-SCDMA, but "allowed" to exist as a complementary to the 'western'[53] standard and building of a "Mixed" network. As a result of the more and more clear vision of TD-SCDMA, more and more enterprises ranging from core network, RAN (radio access network), terminal, chips, testing instrument, antenna to direct amplifier station joined the Industry Alliance in between 2003 and 2005. At this time (2004) the TD-SCDMA R&D and Industrialisation Program(TRIP) was launched by MII,MOST and NDRC (with R&D subsidy of RMB 708 million).

The second tipping point happened in 2006, with the "Hu-Wen New Deal. In Feb. 9 2006 the "National Guideline on Medium-and Long-Term Program for Science and Technology Development (2006-2020)" set out a policy that China should "make the formulation of technology standard as the important target of national S&T program…Guide industry, universities and research institutes to promote the research, formulation and the preferential adoption of the important technology standard". The 11th 5-Year plan of 2006 . moved away from earlier "trading technology with market" to a much stronger focus on "endogenous innovation" policy Ure (2007) quotes Premier Web "*We need to promptly develop core technologies and improve systems integration in some important industries and create technologies, products and standards for which we own intellectual property rights*".

As the flagship standard, TD-SCDMA entered a phase of gaining full support from the 'highest level of the government '. While 'TD' would represent a chance to implement this policy, it would appear that at this point the government leaders also took the decision to back a Chinese mobile telecommunications standard for national strategic ends: mobile phones had become a powerful factor in *national security*[54].

Shortly before this in Jan. 2006, TD-SCDMA was settled on by MII as the "Telecommunication Industry Standard" in China, and stopped all the "excessive-constructed" WCDMA trial networks in progress, in particular China Mobile's trials aimed at launching a 3G service. This decision appears to show a weakening link between China Mobile and the MII. Alongside the new policy of the Hu-Wen government, the maturity of the TD-SCDMA technology itself also enhanced

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http://www.ittime.com.cn/) quoted in (Reimers and Li 2007) However this is disputed by Chinese commentators, who consider that it is over 80% Chinese owned (see.2.3)

[53] The word 'western' is frequently used in Chinese discussions, despite much of the core technology of 3G being Korean or Japanese)

[54] We cannot say for certain, but a range of 'SMS revolutions' around the world, and the growing importance of many-to-many communication via the internet and mobile phone must have been a factor in this top-level interest and commitment

confidence in making this decision. Small scale testing in 3 cities in 2006 proved that TD-SCDMA did not have any inherent technological disadvantages and had the possibility of industrialization and commercialization. However, the absence of the operator was still a big problem.

4.2. Involvement of foreign firms in Chinese TD-SCDMA

As outlined in the introduction, foreign equipment vendors have long had a strong interest in the Chinese market, and their entry has been supported by their governments. China is the largest single market for mobile telecoms equipment, and a key market for their products. They have also had a keen interest, both positive and negative, in the development of TD-SCDMA, and have played a considerable role in the development and commercialisation of the standard. TD development involved the transfer of some of the original TD technology from Siemens, although how much is not clear. Datang, the research institute responsible for TD development worked with the join venture set up by Alcatel, now called Shanghai Bell to integrate TD technology with the full mobile systems provided by Alcatel. There is clearly a two way relationship – the Chinese firms needed to work with major international firms to integrate TD, and these international firms needed to work with Chinese firms to develop products that were TD compatible.

A summary of some of the joint ventures is outlined in Table 1.

Table 1 Example Strategic Agreements and Joint Ventures

National firm	MNO partner	
Datang (research organisation) (strategic relationship from 2004, after early relationship with Siemens broke down)	**Alcatel** (AlcatelShanghai Bell)	'Alcatel Shanghai Bell': Datang integrates Alcatel network tech with TD-SCDMA solution. Alcatel 'industrialise' Datang BSs Datang key institutional link in promoting TD-SCDMA.
ZTE	**Ericsson** (2005)	Strategic alliance. Ericsson to build ZTE's TD-SCDMA technology into it's RAN system
Putian	Nortel Networks then Nokia (2006)	RMB900 million joint between Nokia (49%) and China Putian (51%)[55]
Huawei (joint venture called TD Tech Ltd from 2003)	Siemens	TD Tech owns all of Siemens TD-SCDMA IP.
Source: (Reimers 2007); Ericsson Press release, May 19 2005; (Ure, 2007a, Ure, 2007b)		

4.3. Commercialisation of TD

As a state-owned company, the government gave China Mobile the task of commercializing 'TD'. China Mobile committed 20 billion Yuan (about 2 billion Euro) of investment to build up 10 core network in 8 cities (Beijing and Shanghai had 2 core networks each). Public bidding to supply the equipment started on Mar. 20 2007. The Datang equipment series (including Datang Mobile, Fiberhome, Alcatel-Shanghai Bell, Newpostcom) won 36.68%, ZTE series (including ZTE and Ericsson) won 47.68%, TD Tech series (including Huawei and Siemens) won 13.82%, Potevio series (including Potevio and Nokia) won 2.72%. In the first and second round public bidding for terminals in February and July 2008, domestic enterprises also took most of the share (77.5% and 86%). For comparison it should be noted that Huawei report winning a $700m GSM contract with China Mobile that year, and $7bn of orders worldwide in 2007[56].

ZTE contact was reportedly worth 2.37 billion RMB (US$310 million)[57]. ZTE won most contracts as it was the most prepared. ZTE had invested heavily upfront in TD while there was still considerable uncertainty around the standard. This was not the

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[55] E.g. http://www.cn-c114.net/578/a293854.html

[56] Huawei Press release "Huawei wins USD700 million GSM contract with China Mobile"[Shenzhen, China – 21 June 2007] Huawei Technologies Co., Ltd. And "Huawei Takes the Lead with Over 100 HSPA/WCDMA Contracts" http://www.huawei.com/articles_papers2/simpleres.do?id=1624&type=technology

[57] ZTE, China Mobile sign 3G equipment order (Shanghai Daily) 2007-06-11

case for most non-Chinese international firms, and even Huawei. This early investment also makes ZTE the largest patent holder in TD. ZTE also invested in a multi-standard base station development platform which can be configured to provide wireless access including GSM/UMTS、CDMA2000、TD-SCDMA、FD-LTE、WiMax and TD-LTE which should reduce the transition costs faced by China Mobile as they move to future technologies. Most major vendors of mobile systems and component manufactures are now entering the TD-SCDMA and TD-LTE market in 2009/2010[58], and it remains to be seen who becomes the dominant suppliers of systems and components, and who will profit most. As with UMTS firms, many Chinese and non-Chinese firms are members of a forum to promote TD commercially. Founded in 2000, it was admitted as a Market Representative Partner to the 3GPP in 2005. Currently it has 400 members, including most of the major players in the Chinese market, such as China Telecom, China Unicom, Ericsson, Nokia, Qualcomm, Alcatel, Motorola, Huawei etc [59]

4.4. Industry reorganisation and 3G licensing

2008 saw creation of the super-ministry, the Ministry of Industry and Information technology (MIIT) and appeared more active in promoting TD. Just two weeks after Minister Li Yizhong took his post, the TD-SCDMA entered its testing-commercialisation phase one month earlier than planned. *On May 23 2008, the Ministry of Finance, MII and the NDRC* Notice on Deepening Telecommunications Reform (see 3.2) indirectly criticized China Mobile on the progress of TD-SCDMA, and emphasising that China Mobile had no other choice except devote itself to the development of TD-SCDMA. In the mid of June, Li Yizhong met TD-SCDMA technical experts, and demanded that there could be “no failure but success” in TD-SCDMA, and organised a broad meeting on June 25 to discuss the further advance of TD-SCDMA’s implementation. Just on the next day, the president of China Mobile declared that they will “make every effort” to ensure the excellent service of TD-SCDMA during and after the Beijing 2008 Olympic games. On July 2, MIIT and other related departments founded a cross-ministry coordinating group, and fixed the 34 special work packages for different offices. Finally in July 12 2008, China Mobile formally joined the TDIA and became the first operator member of it. In August 2008 the first licences for TD-SCDMA handset production were issued by the MII, and the first steps towards marketing them announced[60].

In January 2009, the development of future market for telecommunications became clearer. The new ministry finalised the reorganisation of the telecoms industry started in May 2008. The existing 6 companies were consolidated into three main national state-owned companies, who would compete in all telecommunications services. These operators were awarded 3G licences and spectrum[61] [62].

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[58] E.g. “Qualcomm to launch TD-SCDMA and TD-LTE next year”, CAROLINE GABRIEL in Rethink Wireless 18 November, 2009 http://www.rethink-wireless.com/article.asp?article_id=2161
[59] TD-SCDMA Forum. http://www.tdscdma-forum.org/
[60] TDSCDMA Alliance Press Releases (accessed 4 Sept 2008)
[61] . The frequency spectrum they got was: China Mobile 1880-1900 MHz & 2010-2025 MHz, and China Telecom 1920-1935MHz & 2110-2125MHz, while China Unicom 1940-1955MHz & 2130-2145MHz. However, the operators didn’t need to pay expensive fees for using the frequencies

First, China Telecom, took over the CDMA network operated by the old China Unicom, it received a 3G licence to build a new 3G network using the CDMA 2000, and large cash transfer from China Mobile to assist in building the network (other authors suggest this is a government load (Li, 2009). It took over the basic telecoms business of a small operator, China Satcom (who are building the Mobile TV network referred to in D13).

Second, China Unicom, the much weaker of the two national 2G operators, would received a licence to build a 3G network based on the WCDMA (3GPP UMTS) standard and merged with fixed operator, China Netcom.

Third, China Mobile would continue to focus its considerable resources on building a 3G networking using TD-SCDMA, and merge with a small fixed line operator, China TieTong (Railway)

For comparison of the presence of each new firm in the mobile market, figures from commercial estimates (Hire (2009)) in early 2009 suggest that CM has 496.6 GSM subscribers, and 360 000 base stations, China Unicom has 141.1GSM subscribers and 170 000 base stations and China Telecom 41.7 CDMA Subscribers and 40 000 base stations.

4.5. Implementation and Market building

Having developed and commercialised the equipment, 'TD' moves to a new stage, that of building the infrastructure and finding a market for the services it can offer. The previous sections outlined the policies and technical development needed to make a formal standard a realisable technology, and many histories would stop at the point. The history of standardisation, including 3G, is littered with specifications that were formalised but never adopted, so building of an infrastructure, creating 'facts on the ground' is the important part of the story. 'TD' Infrastructure is being built under the direction of China Mobile, but much of the actual work of building the network is being done by the equipment vendors. Nonetheless building alone is not sufficient either, as European 3G operators found to their cost in the early 2000s: China Mobile, along with its competitors has to *build a market* for 3G services as well as the actual infrastructure. It is on the basis of actual use of the TD system that the policy can be judged, and in large part the future need for a 'Chinese' flavour of LTE depends on actually having a TD-SCDMA system in place, parts of which can be upgraded to the next generation. The other reason we are interested in implementation and market building at this stage it to see effect of the reorganisation of the telecoms services market: to what degree has this strengthened the competition with China Mobile, how the 'three operators-three standards' policy will work, and the effect on international competition on the pathway to 4G.

4.5.1. Building the 3G infrastructures

During 2009 the 3G networks are being built rapidly. Figures vary according to source. In the case of China Mobile, the TD network had 20000 base stations by mid

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[62] Spectrum can be allocated in a number of ways e.g. auction, beauty contest, lottery etc and different authorities around the world have choose a number of routes e.g. Andersson et al (2005) with varying degrees of success.

2009. China Mobile planned to spend 58.8 billion RMB on the network, a coverage of 238 major cities (70% of population) with 60 000-85000 base stations (compare 360 000 for GSM) by the end of 2009. During 2010-11 a further 140 000 base stations providing 'nationwide' coverage is expected. However the rival firms are even more ambitious according to data collected by Aeroflex (Hire, S 2009) Unicom propose 80 000 (71000) WCDMA base stations by end 2009 and 70 000 indoor base stations in 334 (285) cities, and China Telecom 500 (342) cities covered with CMDA 1xEV-DO by end 2009.

According to these targets there will be comparable coverage by all three firms.

4.5.2. User adoption: Services and Handsets

Service uptake is also increasing with October headlines such as *"3G Handset Sales achieved 1 Million in China". (Shenzhen Special Zone Daily, 2009-10-20).* . Sales rankings for June 2009 were China Telecom 54%, China Mobile 30%, and China Unicom 16% with handsets from *Samsung, LG and Sony-Ericsson* leading among early adopters. Some sources quote 5.6m as the expected sales by end 2009, a similar figure to the totals collected by Aeroflex: China Mobile: 3m by end 2009, 50-80m by end 2011; Unicom 200000 by end Oct 2009, 20m after 1 year; and Telecom, 1.3m subs June09 and 100m by end 2010.

The main early market for 3G services from all the operators appears to be 3G datacards to allow PC to connect to the internet. Following international trends, China Mobile is subsidizing sales of customised netbook or laptop computers for those taking out subscriptions[63]. Figures to June indicate 1 million 3G modems sold while the sales of handset increased very rapidly in the month 7-10: we can get a general idea that almost 80% of the 3G sales are modems. CDMA2000 modems are selling for 300 RMB.
The other main market that is expected to develop in late 2009 is in smartphones. Apple 3G iPhone has been launched on an exclusive deal with China Unicom, but is also rather expensive for much of the Chinese market. A range of other local and foreign firms are launching smartphones during 2009, and this is an area of development that is exciting, since it offers consumers a powerful interfaces to applications and services that require 3G connection to work. China Mobile and a range of other firms including Dell are supporting the development of a Chinese version of the Google promoted Android system[64], with products such as the originally named 'Ophone' [65]. This is an open-source operating system to compete with the propriety Microsoft, Apple and RIM (Blackberry) systems, and the soon to be open source Symbian (Nokia) system. The development and launch of new devices is at a very early stage, and it is hard to get direct industry information.

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[63] "Chinese telecommunications operator China Mobile has selected six PC makers as its 3G netbook partners" 16 April 2009, China Wireless News http://www.chinawirelessnews.com/2009/04/16/9158-six-pc-makers-selected-as-3g-netbook-partners-for-china-mobile/
[64] Android is a stack of software based on a Linux kernel to enable the development of software applications for mobile phones with consistent network and user interfaces. It was launched by Google in 2008.
[65] "Chinese Ophone Not Just iPhone Imitation" Nov 10, 2009 16:08 Yasushi Uchida, Nikkei Electronics

Of course, the default market is basic telephone services, as occurred in Europe in the first years of 3G launch in Europe. Consumer devices lacked the interface and features to make use of 3G, and video services were often highly priced. Some attempts to sell 3G were made using video and data services, but it would be 2006 before new network technology and devices became available to create services any different of those available on 2.5G networks. However, while there are advantages in building networks with new technology and new spectrum, the main rationale for this investment is an expect market for non-voice. One service that is expected to be popular in China is video calling. This has always been a core feature of 3G services, but while it was very popular in Japan and Korea, it has been much less successful in Europe and North America. This is certainly partly done to pricing, but we await the usage figures and research into use practices to understand uptake in China.

4.6. Future development of TD

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There are three dimensions to the future development of TD technology and policy.

1. The upgrading of TD-SCDMA systems within the TD specification.
2. The move to LTE
3. The export of TD-SCMDA

4.6.1. Upgrading TD-SCMDA

The upgrading of TD-SCDMA systems, increasing performance by introducing a range of enhancements such as new modulation techniques and antennas, providing higher data-rates etc. Many of the techniques are common to all radio systems, and not likely to benefit any particular IPR holder. This will enable China mobile and any other TD-SCDMA operator to improve services over their TD-SCDMA network. However it is not clear to what degree any operator would want to upgrade within TD-SCDMA when LTE will shortly be available.

4.6.2. LTE

The principal question for the developers and supporters of the Chinese TD-SCDMA radio interface is its evolution within the LTE project. The LTE specification has been designed by 3GPP members specifically to provide “*FDD and TDD within a single radio access technology*” in order to “*Avoid unnecessary fragmentation of technologies for paired and unpaired band operation*” (Chairman of 3GPP presentation of LTE to the ITU 2009 (Nakamura 2009)), clearly a direct reference to the Chinese pursuit of TD in 3G.
‘Evolution’ TD-SCDMA is basically LTE run in TD duplex mode (LTE-TD) (Guangyi, Jianhua et al. 2005), and has little to do with TD-SCMA: TD-LTE operates in unpaired spectrum, as does TD-SCDMA, but otherwise it shares both MIMO scenarios and the up- and down-link modulation formats with the FDD mode[66]. LTE-TD is supported by Chinese and international firms[67]. However China has insisted

[66] OFDMA in the downlink and SC-FDMA in the uplink
[67] e.g. ‘Nokia Siemens supports TD-LTE tech rollout’ EE Times Asia, 6 March 2009, “TD-LTE can catapult China to advanced next-generation mobile broadband services, and we are committed to

that in the submission to the ITU-R, two separate, and almost identical specifications, one for TDD and one for FDD modes should be presented[68]. Exactly what this separation is meant to signal, and to whom, is open to investigation.

During 2008 there were a number of conferences addressing the question of LTE and TD-SCMA[69]. In 2009 the Chinese government started investing considerably in a 'Chinese' post-3G TD programme, and during late 2010 'TD-LTE' started to be integrated in to chipsets and test equipment, and tested in various trials[70][71]. Probably most importantly this work ensures that TD-LTE specifications can provide a certain degree of backwards compatability and enable call hand-over on multi-standard devices to legacy systems installed in China, including TD-SCDM, WDCMA and GSM (Hire 2009). Investment in TD-LTE would appear to be a direct continuation of the 'TD' policy, as discussed in the next section. It may ensure a specification within which Chinese firms may be able to develop IPR within with less competition, or it may be a way to maintain the visibility of the 'flagship' TD policy developed in 3G. It still remains to be seen how far the 'TD' approach will develop and implemented in LTE and LTE Advanced, and how it will actually be deployed in Chinese and other markets, although China Mobile has consistently claimed that it will move to LTE trials and implementation earlier than many other major operators[72]. Theoretically China Mobile could upgrade to LTE in the FD mode just as easily as TD mode, if it were licensed paired spectrum bands, but given the history one would expect tem to be licensed to operate in TD mode.

Many firms are now investing in TD-LTE, although only China Mobile are currently doing early trials with the announcement they will deploy TD-LTE for the Shanghai Expo, and conduct the large-scale test in at least 2 cities with over 100 base stations from the second season of 2010.

4.6.3. TD-SCDMA for export

The third dimension of TD development is in the expansion of the market outside of China. While Chinese firms and policy makers have generally discussed TD as a China-only standard, with the recent implementation, there appears to be a shift to an export policy. While Chinese vendors, such as Huawei are supplying equipment to all standards, there are some features of the technology, and of Chinese policy

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putting significant resources to support its development and deployment," said Marc Rouanne, head of the company's radio access business. "
http://www.eetasia.com/ART_8800565548_499488_NT_2af25beb.HTM

68 Submission to ITU coming through 3GPP will be presented as a
"FDD Radio Interface Technology component (FDD RIT) and as a TDD Radio Interface Technology c omponent (TDD RIT). Together the FDD RIT and the TDD RIT comprise a Set of Radio Interface Tec hnologies (SRIT)" 3GPP RAN Chairman's presentation to the ITU-R WP 5D Third Workshop on IMT-Advanced 15 Oct 2009.

69 E.g. TD-SCDMA Evolution and LTE Summit, Shanghai 2008 http://www.tdscdma-forum.org/EN/events/luntan/83.asp

70 e.g. Huawei Deploys World's First TD-LTE Trial Network for 2010 Shanghai World Expo, Nov 16, 2009 Nikkei Electronics Asia

71 e.g. TD-LTE technology and its measurements, Yvonne Liu and Bai Ying, Agilent Technologies. EDN Asia, 1 Nov 2009 http://www.ednasia.com/article-24996-tdltetechnologyanditsmeasurements-asia.html

72 China Telecom/Unicom have announced they have chosen LTE as their 4G network technology.

that might suggest there are external markets. a) Since one of the business factors of TD is the low IPR costs, equipment and devices might be cheaper , making them more attractive to foreign buyers, particularly low to medium income countries. b) China has a foreign aid programme that includes the supply of subsidised or free telecoms equipment. It would be surprising if this did not include TD equipment. C) As vendors of TD-SCDMA components and systems develop their supply, then they too will be looking for markets outside China. TD-LTE, being an integral part of the single LTE standard may suit markets with unpaired spectrum or with conditions where TD is more appropriate, and Chinese vendors may have some commercial advantage in their supply of LTE-TD systems over non-Chinese firms, but it is not at all clear that this would be the case or a deciding factor.

5. Towards an Analysis of the TD policy in China

There are a number of policy questions that this raises, and provides some of the material to answer them. However the majority of analysis will be contained a future deliverable. This report will only brief discussion and conclusion. There are some historical questions, largely on the evolution of substantive policy, and policy making in China that we can learn through this case, particularly related to the opening of markets both internally and internationally, and the learning associated with making this happen. There are also specific questions to be answered about process and the outcome of the TD policy. This document touches on some of these, but also leaves them as placeholders for analysis in the final part of the project.

5.1. The Three-Standard Decision.

The Chinese's government's decision to award licences for 3 different 3G system is of interest analysts of the link between standards and innovation policies, especially in telecommunications. While the largely free market approach of the US, with its support for decision making at a corporate level would be expected to result multiple standards being deployed, China would generally be considered to be more similar to European and other more interventionist states, that have generally favoured a single standard approach to facilitate competition at consumer level and benefit from the economies of scale of one system. However, unlike Europe, China's main policy aim is not to produce a single market out of fragmented national markets, but to create competition for economic efficiency and service improvement, while maintaining state control over telecommunications.

The long delay in creating licences for 3G mobile, compared to many other countries around the world, is linked to the indecision over policy, and the need to bring TD-SCDMA to maturity as a commercialisable system. However, with this delay, why licence two other standards, and mandate a reorganisation of the telecoms industry in a way that two smaller, and generally weaker firms have the established international standards, and the dominant player, China Mobile, the Chinese standard?

China Mobile is the firm with the best resources and market access to make TD-SCDMA a success throughout the country. It may struggle with a more immature technology, but since it is under obligation to develop it, then this is likely to be only a short term problem. What are the benefits of pushing China Telecom, with no mobile experience or market, and China Unicom, a weakly managed firm with urban-only

coverage into the 3G market with incompatible standards? Will this really create a successful competitive market, or is it as some commentators suggest, a backup policy in case China Mobile fails to deliver?
Finally, has the State Council finally loosened the telecoms operators from the ministries that used to be associated with them, and created an effective market of three operators who will not only offer a full range of telecommunication services, but also improve customer service, innovate in services and invest in new infrastructure?

5.2. Policy Outcomes

Through the development of TD, a variety of arguments have been made in favour of the policy to support its development and implementation. While it is too early to be able to fully analyse the benefits or failures of the policy, were are able to list the main issues.

1. *A Chinese standard is needed to reduce the costs of 3G implementation in China*: this is likely to be the case, particularly if IPR costs of future mobile systems are considerably lower than international competitors. As a social policy to reduce the cost of 3G networks it may work, but it is not clear how much saving there actually is.
2. *A Chinese standard is necessary to enable Chinese equipment manufacturers to development the R&D and manufacturing strength*. TD has certainly given Chinese research institutes considerable confidence in their ability. It may also have enabled large firms like Huawei and ZTE to develop capability. However these firms grew in international stature before finalisation and implementation of TD, and are able to supply equipment of all standards internationally. In terms of standards processes particularly in 3GPP, but also elsewhere, Chinese players have **become more confident in participation in international standards making processes, being more active, and taking leadership roles**. However this report has not addressed the situation of the many SMEs involved in telecoms technology development, and the way that regulatory change including standards processes and IPR has benefited them.
3. *China needs its own technology and standard for mobile telecoms, given that this is a key strategic infrastructure for economic, social and political development*. This may be the case, however ownership of the IPR for a part telecommunications system that are owned and developed across many countries may not be important. However indigenous capability and confidence could be an important national asset in creating telecommunications infrastructures that suit the political goals of the Chinese government,

5.3. Policy Evolution

The TD case seams a good example of the evolution of policy. Initially the TD policy is based on two arguments:
1. An ambition develop indigenous technological capability, including IPR in technologies that can be accepted in international standards, if only implemented in China
2. To reduce the costs of licensing falling on Chinese vendors, and network operators buying from abroad.

However by 2009, with the launch of the TD systems, these seem to have mutated
1. TD is a National Flagship: it demonstrates China's technological capability
2. It is Strategic National Asset
3. TD is a mechanism to become a global player

National systems of Innovation literature has identified a continuum of policies, from Techno-nationalism to Techno-globalism in Reich's terminology (Reich 1987, quoted in Lee, Chan & Oh 2009) to characterise these policies. Based on analysis of telecommunications policy, Suttmeier and Yao (2004) suggest that standards after analyzing the WAPI case, offer a relatively comprehensive evaluation of China's standards policy as a whole. They concluded that China's standards policy is neo-techno-nationalism. Moving forward to 2009, in the techno-globalism v. techno-nationalism analysistere would appear to be a shift from a fragmented policy, rather more on the nationalist side, to one that is more unified and globally focused. This was clearly *not* a planned evolution, but a result of numerous developments in national market/policy development and the international market.

5.4. A comparison of China and the EU Policy and Industry

Table 2 below, outlines various issues relevant to the complexity of standardising convergence in respectively China and the EU at policy, regulatory, equipment vendor, operator, network and device levels. The content of the table is discussed in the ensuing subsections.

Table 2 A six-layered analysis of mobile telecoms development in China and the EU

	China	European Union
A. Policy	• Indigenous technology policy to strength industry internally and in foreign markets • Policy efforts, primarily by MII were not taken particularly seriously outside until top level government support provided • TD promoted by Telecoms ministry/regulator (now MIIT) • Role of media ministry not currently important (SARFT), but may become so. • Policy to support national equipment industry through TD standard in tension with operators' desire to select technology and build 3G networks – led to delays in licensing.	• Harmonisation of market, and support of industry against foreign competition • GSM seen as success of European Policy. 3G prompted the same way. 3GPP seen as successful development of 'European Way' • EU selection of 3G (EC and Council of Ministers)not entirely successful with hindsight. Different approaches to licensing across Europe. • Less commitment to 4G than previous generation – diverse approaches to spectrum release (e.g. UK backed spectrum trading) • Industry policy supporting vendors in tension with regulatory policy on services
B. Regulator	• Regulation currently straightforward, though MIIT • Not clear to what degree internal division in Regulator exist, and the degree of independence from other government bodies, and from the managers of the operators	• Nationally coordinated regulators, but no EU super-regulator • Different national approaches, certainly dependent on presence of national technology champions, and political influence of operators • Attempts to harmonise regulation ongoing
C. R&D and Vendors	• National vendors weak in 1990s, and with little national presence in supply of 2G. • Still relatively weak Chinese research expertise, although strong in development • Very strong growth in 2000s from local and expert markets. Huawei and ZTE now major international players with considerable IPR portfolios and presence in international standards processes • Slow commitment to TD investment until top level policy backing • Large and medium size firms dominating manufacturing in mobile equipment on all standards. • National firms win majority of TD infrastructure contracts form China Mobile	• Range of National champions in mobile telecoms equipment. • Some firms strong than others, all have relied on Chinese market for income from GSM • EU and US firms still dominate IPR development in mobile telecommunications • European firms loosing orders to Chinese firms
D. Operator	• China Mobile, the largest and most successful operator 'burdened' with the task of commercialising TD 3G. • Other operators awarded licences for competing foreign standards, but unclear how they can successful compete with China mobile, expect by drawing on mature of supply of equipment and consumer devices	• Operators stung by technical problems, lack of cash and lack of market with early launch of 3G at peak of dot-com bubble. • Continued consolidation of operators in European market • Operators generally conservative, slow to introduce new services. • Strong growth in wireless data market, but long-term profitability model unclear. • Most operators still cautious about major investment in next generation equipment, especially with economic crisis.
E. Network	• Fast network build in 3G by all operators China Mobile. Trials of LTE • Plans for 4G spectrum not announced	• 3g networks established in most European countries. • Many networks upgraded to HSPA standard for mobile broadband. • Some trials with HSDP and LTE. • Plans for 4G spectrum not announced, not harmonised
F. Device	• Devices must conform to standard. • Operators can and do subsidise devices to attract customers. • Relatively low supply of TD compatible devices leads China Mobile to attempt to stimulate supply • Smartphones intended for high-income market expensive • Development of lower cost smartphones from Chinese and international suppliers, based on open source software (Android, Symbian, other Linux) likely to open mobile broadband market • Initial 3G market focused on laptop and netbook internet connectivity.	• Devices must conform to standard • Devices generally selected and prompted by operators, but varying regimes of subsidy across Europe. • Segmentation of mobile broadband into connections for laptops and netbooks, and handheld devices (phones, smart-phones) • Continued struggles with business models for new consumer devices and content.

6. Summary

The mobile communications industry has been through a difficult period of innovation, but has successfully emerged with a ‘3G’ system that has been rolled out in various forms around the world. In particular the WCDMA system specified by 3GPP is now entering a stage of maturity meaning lower costs and high reliability. Even as recently as 2008 analysts were wondering if the Chinese-specific standards policy would lock the Chinese market away from international players and tie national vendors of all sizes into a China-only mobile world. With the Three Standards-Three Firms decision, and the continued success of Chinese vendors abroad these worried would appear to be unfounded.

The TD process has undoubtedly been led, although at times shakily, by elements of the Chinese government and key Chinese stakeholders, it has also depended on a number of multinational telecoms firms. While the story of TD-SCDAM is often told as the struggle of China against over priced products of international telecommunications vendors, it is clearly a more complex story, as several of those vendors have been integral to the development and promotion of TD-SCDMA systems. Chinese government policy emerged to favour a national standard, but not so much to favour local industry domestically, but to further goals of national security, and to allow national firms to play are greater role in global markets. However during the 2000s, Chinese telecoms equipment vendors such as Huawei and ZTE have grown to be extremely strong global players in fixed and mobile systems, without the help of a ‘national standard’. Nonetheless, the TD-experience appears to have helped the Chinese national Standards Bodies and vendors gain confidence in participating in Global Standards consortia.

The TD-story is part of a larger political and economic development] mirrored in all areas of the world: that of the reform of the governance of telecommunications, from the innovation, standardisation and supply of equipment to build infrastructures to the shaping of the market for services. China and Europe have pursued regulatory reform and market competition with varying success since the launch of 3G in 1998, and will change considerably. European States and the EC may not be able to mandate industry reorganisation, but regulatory change and the allocation of spectrum is often followed closely by ‘market-led’ industry reorganisation (as happens in the US too). Nonetheless we must not underplay the importance of total state ownership of telecoms operators in China.

From a European Perspective, the evolution of 3G to LTE is a move by the firms involved to a global platform for standardisation and competition, a move facilitated by the shift in governance structures of standards development to the 3GPP consortium that appears to have weathered the 2000s in good shape. From an European Harmonisation perspective 4G does not appear to add to 3G, but can be seen as a successful continuation of a policy aimed at ensuring a common standard for European businesses and consumers that will bring important competitive and welfare benefits. For European Policy makers concerned with ensuring that European telecoms vendors remain internationally competitive, it appears that the success of 3GPP involving Chinese firms is also a success, keeping companies such as Ericsson, Siemens and Nokia at the forefront of technology development, even if they are loosing orders to Huawei and ZTE. However 4G is far from resolved, and there are still at least 5 years before implementation.

This report provides evidence to be used in a cross-cutting analyse of the role of standards and standards policy in innovation policy. The parallel reports on Mobile TV and AVS offer contrasting cases, and included details of standards, industry and policy processes in China and Europe that complement that found in this document.

7. References

3GPP2. (2008). "System Release Guide for the UMB-1 Release of the cdma2000 System Specifications." from http://www.3gpp2.org/public_html/Specs/SC.R2005-002-0_v1.0_UMB-1_SRG_080521.pdf.

Andersson, P., S. Hultén, P. Valiente (2005). "Beauty contest licensing lessons from the 3G process in Sweden." Telecommunications Policy 29(8): 577-593.

Bauer, J. M. (2005). "Regulation and state ownership: conflicts and complementarities in EU telecommunications." Annals of Public & Cooperative Economics 76(2): 151-177.

Bekkers, R., G. Duysters, et al. (2002). "Intellectual property rights, strategic technology agreements and market structure: The case of GSM." Research Policy 31(7): 1141-1161.

Bekkers, R., B. Verspagen, et al. (2002) "Intellectual property rights and standardization: the case of GSM." Telecommunications Policy 26(3-4): 171-188.

Cai, J. and A. Tylecote (2008). "Corporate governance and technological dynamism of Chinese firms in mobile telecommunications: A quantitative study." Research Policy 37(10): 1790-1811.

Cave, M. (2007). "Six Degrees of Separation Operational Separation as a Remedy in European Telecommunications Regulation." COMMUNICATIONS & STRATEGIES 64(4th quarter 2006): 89-103

de Streel, A. (2008). "Current and future European regulation of electronic communications: A critical assessment." Telecommunications Policy 32(11): 722-734.

Fomin, V ,(2000) "Equilibrium and Transformation in the Standard Making Process" (2000). PACIS 2000 Proceedings. Paper 46. http://aisel.aisnet.org/pacis2000/46

Fomin, V. and T. Keil (2000). Standardization: Bridging the gap between economic and social theory. Proceedings of the 21st international conference on information systems, Dec 2000, Brisbane, Australia.

Fransman, M. (2002) Mapping the Evolving Telecoms Industry: The uses and shortcomings of the layer model Telecommunications Policy , Volume 26, Issues 9-10, pp 473-483.

Funk, J. L. (1998). "Competition between regional standards and the success and failure of firms in the world-wide mobile communication market." Telecommunications Policy 22(4-5): 419-441.

Funk, J. L. and D. T. Methe (2001). "Market- and committee-based mechanisms in the creation and diffusion of global industry standards: the case of mobile communication." Research Policy 30(4): 589-610.

Gao, P. and K. Lyytinen (2000). "Transformation of China's telecommunications sector: a macro perspective." Telecommunications Policy 24(8-9): 719-730.
GAO (2004). Technology Assessment. Cybersecurity for Critical Infrastructure Protection. U. S. G. A. Office, United States Government Accountability Office.
GAO 2009 "Financial Regulation A Framework for Crafting and Assessing Proposals to Modernize the Outdated U.S. Financial Regulatory System." Jan 8 2009, US Government Accountability Office
Guangyi, L., Z. Jianhua, et al. (2005). Further Vision on TD-SCDMA Evolution. 2005 Asia-Pacific Conference on Communications.
Hire, S (2009) From TD-SCDMA to TD-LTE , Presentation to 4G Wireless Broadband Evolution seminar - Hong Kong, September 7, 2009
Harwit, E. (2008) China's Telecommunications Revolution. New York: Oxford University Press.
ITU-R. (2003). "Framework and overall objectives of the future development of IMT 2000 and systems beyond IMT 2000." from http://ieee802.org/18/Meeting_documents/2007_Jan/R-REC-M.1645-0-200306-I!!MSW-E.doc.
ITU (2003a). Recommendation Y.2091 (03/07) : Terms and definitions for Next Generation Networks. Geneva, ITU-T.
ITU. (2003b). "Recommendation ITU-R M.1645 Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000 (Question ITU-R 229/8), ITU, 2003." from http://ieee802.org/secmail/pdf00204.pdf.
ITU. (2003c). "Resolution ITU-R 52 - Authorization for the Radiocommunication Advisory Group (RAG) to act between Radiocommunication Assemblies (RAs)." from http://www.itu.int/dms_pub/itu-r/opb/res/R-RES-R.52-2003-PDF-E.pdf.
ITU (2005) Guidelines on the smooth transition of existing mobile networks to IMT-2000 for developing countries (GST),ITU-D Study Group 2, ITU http://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG02.18-1-2006-PDF-E.pdf
ITU. (2007b). "ITU-R Radiocommunication: The future is wireless." from http://www.itu.int/dms_pub/itu-r/opb/gen/R-GEN-OVW-2007-E10-PDF-E.pdf.
ITU. (2008a). "Common Patent Policy for ITU-T/ITU-R/ISO/IEC." from http://www.itu.int/ITU-T/dbase/patent/patent-policy.html.
ITU. (2008b). "ITU Radiocommunication Study Groups, Working Party 5D Background on IMT-Advanced, Document IMT-ADV/1-E, 7 March 2008." from http://www.itu.int/ITU-R/index.asp?category=study-groups&rlink=rsg5-imt-references&lang=en.
ITU. (2008c, Jun. 19). "Next Generation Networks Global Standards Initiative." ITU Retrieved Aug. 28, 2008, from http://www.itu.int/net/about/itu-t.aspx.
ITU. (2008d, 06/16/2008). "TU-T Study Group 16 - Multimedia terminals, systems and applications." ITU Retrieved Aug. 28, 2008, from http://www.itu.int/net/ITU-T/info/sg16.aspx.
Iversen, E. (2000): Standardization and Intellectual Property Rights: Conflicts Between Innovation and Diffusion in New Telecommunication Systems, in: Information Technology Standardization: A Global Perspective, edited by Kai Jacobs, Idea Group
Publishing: Hershey, London, pp. 80-101
Kammerlander, K. (2000). Benefits and implementation of TD-SCDMA. Communication Technology Proceedings, 2000. WCC - ICCT 2000. , Beijing.

Lee, H, Chan and Oh. (2009). `China's ICT standards policy after the WTO accession: techno-national versus techno-globalism'. Info - The journal of policy, regulation and strategy for telecommunications 11(1):9-18

Lehr, William and Thomas, Kiessling (1999), "Telecommunication Regulation in the United States and Europe: The Case for Centralized Authority," in Competition, Regulation and Convergence: Trends in Telecommunications Policy Research, S. E. Gillett and I. Vogelsang (Eds.), Lawrence Erlbaum Associates, Mahwah, NJ, 1999.

Li (2008) G. Li, Moving towards the unsustainability—A study of chinese telecommunications regulation, International Journal of Private Law 1 (1) (2008), pp. 47–64.

Li, G. (2009). "Can the PRC'S new anti-monopoly law stop monopolistic activities: Let the PRC'S telecommunications industry tell you the answer." Telecommunications Policy 33(7): 360-370.

MII, NDRC, & Treasury (2008) MII, NDRC, & Treasury. (2008). A notice of deepening reform in telecommunications sector.

Moiin, H. (2006). Next Generation Mobile Networks Beyond HSPA & EVDO. London, NGMN Alliance. http://www.ngmn.org/fileadmin/content/documents/downloads/White_Paper_-_Beyond_HSPA_and_EVDO.pdf (4/09/08)

Keiji Nakatsuji (2001) Essence of Trade Negotiation: A Study on China's Entry for WTO, Ritsumeikan Annual Review of International Studies, vol14-1 :015-34

Nakamura O and Kerr C (2008) Current Status of Platform 2008 WCDMA and its Joint Patent Licensing", NTT DOCOMO Technical Journal Vol. 10 No. 3

Noam, E. and D. Steinbock (2002). Competition for the Mobile Internet, Kluwer. http://www.3glicensing.com/articles/DOCOMOTechnicalJournal_vol10no3.pdf

NDRC (2007) The Outline Of The Eleventh Five-Year Plan For National Economic & Social Development Of The People's Republic Of China : Profile. Accessed 14 Oct 2008 from http://en.ndrc.gov.cn/hot/t20060529_71334.htm

Ofcom. (2008). "Ofcom awards spectrum licence to Qualcomm UK Spectrum Ltd (News Release)." Office of Communications Office of Communications Retrieved May 23rd 2008, from http://www.ofcom.org.uk/media/news/2008/05/nr_20080516b.

Pelkmans, Jacques (2001) 'The GSM standard: explaining a success story', Journal of European Public Policy, 8: 3, 432 — 453

Reimers, K. and M. Li (2004). Effectiveness of Governance Structures for 3G Standardisation and Implications for China's 3G Policy. Adoption and the Knowledge Economy: Issues, Applications, Case Studies. P. Cunningham and M. Cunningham, IOS Press: 256-270.

Reimers, K. and M. Li (2007) Effectiveness of the International 3G Standardisation Process and Implications for China's 3G Policy. International Journal of Public Policy, Vol. 2, Nos. 1/2, pp. 124-139.

Rongping, M. and W. Zhuoliang. (2005). "The Role of Standards in National Technology Policy in China." from http://www.law.gmu.edu/nctl/stpp/us_china_pubs/6.10_Role_of_Standards_in_National_Tech_Policy_in_China.pdf.

Rudin, R. (2006). "The Development of DAB Digital Radio in the UK: The Battle for Control of a New Technology in an Old Medium." Convergence 12(2): 163.

Rumney. (2008). "3GPP LTE: Introducing Single-Carrier FDMA." from http://www.home.agilent.com/agilent/redirector.jspx?action=ref&cc=US&lc=eng&ckey=1361941&cname=AGILENT_EDITORIAL.
Shen, X. (1999). The Chinese Road to High Technology - the Case of Digital Telecommunications Switching Technology in the Economic Transition. London and New York: Macmillan and St. Martin.
Tan, Z. (1994). "Challenges to the MPT's Monopoly". Telecommunications Policy. 18 (3) 174-181.
Tan, Z. (1999). "Regulating China's Internet: convergence toward
a coherent regulatory regime". Telecommunications Policy 23 (3-4) 261-276.
Treacy, P. and S. Lawrance (2007). "FRANDly fire: are industry standards doing more harm than good?" Journal of Intellectual Property Law Practice: jpm212.
UMTS Forum. (2008). "Towards Global Mobile Broadband: Standardising the future of mobile communications with LTE." from http://www.umts-forum.org/component/option,com_docman/task,doc_download/gid,1904/Itemid,12/.
Ure, J. (2003). "Deconstructing 3G and reconstructing telecoms." Telecommunications Policy 27(3-4): 187-206.
Ure, J. (2007)a. Study 5: ICT Equipment Study on the Future Opportunities and Challenges in EU-China Trade and Investment Relations 2006-2010. European Commission.
Ure, J. (2007)b. Study 10: Telecommunications Services. Study on the Future Opportunities and Challenges in EU-China Trade and Investment Relations 2006-2010, European Commission.
Vincent (2007) Low Cost 3G Devices, How Can We Achieve the Balance in IPR Needed to Afford 3G for All?, 3glicensing , Presentation at Low Cost 3G Devices" conference, London 2007 http://www.3glicensing.com/articles/News%20LowCost.pdf
John Ure J (2007)c China Standards and IPRs , Working Paper for the EU-China Trade Project, April 2007) http://www.trpc.com.hk
Zhiyuan Ge, Jiang Yu, Ping Gao, "The "Silk" Road to 3G: Mobile Telecommunications Market Innovation in China," Mobile Business, International Conference on, pp. 335-339, 2009 Eighth International Conference on Mobile Business, 2009.