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**APT REPORT ON**

**NETWORK SYNCHRONIZATION TECHNOLOGIES   
IN RADIO ACCESS NETWORKS FOR IMT TDD systems**

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**APT REPORT ON   
“NETWORK SYNCHRONIZATION TECHNOLOGIES   
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# Introduction

TD-LTE networks are developing very quickly around the world along with the refarming of TDD spectrum from WiMAX networks/other mobile networks to TD-LTE networks and with the gradually increased utilization of unpaired TDD spectrum. In the Asia-Pacific area, the number of TD-LTE networks is increasing fast in recent years.

When more than one TDD networks owned by different operators are deployed in the adjacent frequency block in the same band and in the same geographic area without inter-operator synchronization, or when TDD base stations (BSs) with different ratio between uplink and downlink are deployed in the adjacent frequency block in the same band and in the same geographic area, severe interference may occur on BS or mobile terminal sides due to lack of synchronization. Such interference caused by not being synchronized may be eliminated to some extent by employing guard bands and engineering solutions, e.g., additional filters and/or site isolation for BSs. However, these solutions are to eliminate the interference at the cost of increased OPEX/CAPEX, low spectrum utilization and complicated site engineering. Therefore, synchronization is an essential issue to be resolved when the TDD networks are operated in the adjacent frequency block in the same band and in the same geographical area.

Traditional synchronization solutions, e.g. by GPS or by Ethernet, bring benefits. However, these solutions have their respective conditions and limitations in deployment scenarios and requirements which are also associated with new IMT technologies.

Considering the abovementioned issues, studies on TDD network synchronization technologies in the radio access networks for IMT will focus on the following items: issues associated with TDD synchronization, category of spectrum and compliance activities considered in the view of management, solutions required to ensure network synchronization, and impacts from synchronization technologies.

# Current status and future plan of network synchronization in APT countries

The 2 500-2 690 MHz band is identified for IMT in three Regions in the ITU Radio Regulations. Refer to the arrangement C3 in Recommendation ITU-R M.1036, China has issued a full TDD arrangement in this band in late 2013. Three TDD licenses are assigned to three mobile operators to construct TD-LTE networks in the main land of China without any frequency guard band. China Unicom, China Mobile and China Telecom are assigned with the frequency 2 555-2 575MHz, 2 575-2 635MHz and 2 635-2 655MHz, respectively. TDD synchronization technologies are adopted by operators in this scenario and no interference issues have been reported so far. The number of TD-LTE subscriptions grows fast, and there are more than 80 million subscriptions using TD-LTE by the end of 2014 in China.

The 2 300-2 400 MHz band is identified for IMT in three Regions in the ITU Radio Regulations. Currently many countries in Region 3 (such as China, India, Indonesia and other countries) allocated the 2 300-2 400MHz band for IMT. In accordance with Recommendation ITU-R M.1036, there is only one frequency arrangement scheme for the 2 300-2 400MHz band which is a TDD arrangement.

Furthermore, the 3 400-3 600 MHz band is identified for IMT in some countries in Regions 1 and 3 in the ITU Radio Regulations. In some countries in Region 3, TDD networks are deployed or planned to be deployed in this frequency band.

The scenario of more than one TDD networks deployed in the adjacent spectrum blocks in the same geographic area may happen in some countries in these frequency bands.

# Relevant activities regarding network synchronization

***GTI***

More and more TD-LTE networks have been deployed around the world because of the fast global development of TD-LTE industry. To enhance the maturity of TD-LTE industry, China Mobile drafts a white paper of TDD synchronization in GTI (Global TD-LTE Initiative).

The white paper consists of analysis on necessity of synchronization in TDD networks, accuracy requirements on synchronization, synchronization schemes, evaluations on performance and application scenarios for different schemes, deployment suggestions, etc. Both GNSS (Global Navigation Satellite System) scheme and IEEE 1588v2 scheme can satisfy synchronization accuracy requirement well. But the two schemes are limited in deployment scenarios. For instance, they are sensitive to deployment cost and uplink transmission environment. Compared with the two schemes, air interface synchronization scheme is more flexible in terms of low cost and restrict uplink transmission requirement (e.g. home e-Node B).

***CEPT***

ECC Report 216 provides “Practical guidance for TDD networks synchronization” to address the synchronization issue for TDD networks.[[1]](#footnote-1) The Report in particular states that a common reference phase clock (e.g., for the start of frame) and configuring compatible frame structures (e.g., length of frame, TDD ratio, etc.) are the two conditions which need to be followed on all base stations that may interfere with each other in a given geographical area in order to achieve a synchronized operation. Furthermore, the Report provides a description of the currently available techniques for transmitting a reference phase clock which includes: global navigation satellite systems (GNSS), packet based networks, over-the-air synchronization, and “LORAN” (reference signal transmitters mounted on high towers and based on either Loran-C or eLoran format, depending on the country). It also suggests that when multiple operators deploy TDD networks in adjacent frequency bands inter-network synchronization conditions can be discussed and agreed at a national level.

***ITU-R WP5D***

In its 12th meeting of ITU-R Working Party (WP 5D), India proposed to initiate a study on coexistence of two TDD networks in the 2 300-2 400 MHz band. The proposal was approved and the corresponding working document was created. Currently, the working document contains sections such as description of interference scenarios, synchronization of TDD networks, interference analysis under unsynchronized TDD networks, etc.. According to the preliminary study result, a 33 dB additional isolation requirement at the receiver and a 53 dB additional isolation requirement at the transmitter are required as additional filter requirements under the conditions of 50 dB MCL for unsynchronized macro BS and a 5 MHz frequency guard band.

The study in ITU-R WP 5D is planned to be finalized in its 22nd meeting in June 2015.

# TDD network synchronization solutions

## 4.1 Frame setting requirements for TDD synchronization

Serious interference will occur if TDD networks of different operators in the same area are neither synchronized nor arranged given uplink and downlink time slot settings. For instance, a transmitter of operator A is transmitting while a receiver of operator B is trying to obtain its own signal at the same time. The receiver of operator B has chances of being blocked or getting its noise floor dramatic raise, due to the out-of-band emission of transmitter of operator A and un-ideal adjacent channel signal selection of receiver of operator B. Additional frequency guard band or transmitter filter or other interference elimination solutions are required in this example.

However, considering increase of equipment updating cost and enhanced frequency utilization, TDD synchronization solution is preferred in the scenario of multiple TDD operators in the same area. The solution is to consult predefined TDD frame settings among the operators. Basically TDD base stations for all the operators shall transmit or receive in the very same time slot, so that no interference exists among equipment of different operators. Technically this requirement turns out to be the following two requirements:

(1) Each operator has the same TDD frame starting point;

(2) Each operator uses the same TDD uplink and downlink time slot setting. The agreed frame setting uses uniformed uplink and downlink time slot setting, while the special sub-frame is not required to be the same. To keep the coverage consistent, two OFDM symbols overlay in Guard Period is requested in special sub-frame.

## 

## 4.2 Synchronization techniques

According to the synchronization requirements in 3GPP TS.36.133, TD-LTE base station output carrier signal frequency accuracy should be less than 0.1 ppm, and the cell phase synchronization accuracy applied to the overlapping cells should be equal or less than 3 us for the cell radius up to 3 km. Available techniques to meet these requirements include: GPS synchronization scheme, IEEE 1588v2 synchronization scheme and air interface synchronization scheme.

* **GPS synchronization scheme**

Representative global satellite navigation systems are US’s GPS (Global Positioning System), China's Beidou satellite navigation system, Russia's Glonass, and Europe's Galileo. These global satellite navigation systems can provide the timing accuracy of less than 100 ns.

GPS synchronization scheme is widely used in current TDD systems. GPS receivers could be deployed in TDD base stations of different operators in the same region. In this way, base stations of different operators will use the same GPS standard time, so that frames in each base station are synchronized. Additionally, frequency synchronization information could be obtained via GPS signal which could be used to satisfy the requirement of output carrier signal frequency accuracy in 3GPP TS.36.133.



Fig. 1 GPS synchronization scheme for multiple TDD operators in the same region

* **IEEE 1588v2 synchronization scheme**

IEEE 1588v2 synchronization scheme is widely used in control system synchronization protocol and standards. It keeps synchronization between the most accurate clock and other clocks in the system. To realize this target, a Precision Time Protocol (PTP) is defined in IEEE 1588v2. PTP is used for synchronization of sensors and other terminal devices in distributed bus systems at sub-microsecond level. Frequency synchronization can be realized by synchronization in PHY layer in Packet Transport Network (PTN). Thus IEEE 1588v2 is utilized in such systems for time synchronization instead of GPS.

Delay-Request measurement mechanism is adopted in IEEE 1588v2, used mainly for networks using ordinary clock, boundary clock or transparent clock terminals. The procedure is depicted in the following figure.



Fig. 2 Delay-Request measurement mechanism in IEEE 1588v2

For different operators, IEEE 1588v2 interface could be used to obtain inter-operator synchronization. The connection setup for this condition is shown in the figure below.



Fig. 3 IEEE 1588v2 synchronization scheme for multiple TDD operators in the same region

Time synchronization system in this scheme consists of four parts, namely time source (such as GPS, Beidou, or other satellite navigation system), time synchronization device, transport network (usually deployed as ring bear) and TDD base stations. All the devices in Figure 3 from the time synchronization devices of different operators at the top to the TDD base stations at the bottom use IEEE 1588v2 as their interfaces to other devices. For the time synchronization device of each operator, a common timing system should be used to guarantee the unique time resource for each operator.

* **Air interface synchronization scheme**

Air interface synchronization schemes designed to be used for small cells are currently under discussion in 3GPP. Synchronization by GPS or synchronization by IEEE 1588v2 is not always available for small cell deployments (e.g. indoor deployment, hotspots with high buildings around). Additional cost required for implementing GPS or IEEE 1588v2 is also of concern especially for small cells. Therefore, it is beneficial to have an air interface synchronization scheme when GPS or IEEE 1588v2 based synchronization is unavailable. Air interface synchronization schemes are then proposed in 3GPP TR36.872 to present synchronization among small cells as well as synchronization between small cell and overlaid macro cell.

The air interface synchronization scheme is shown in Figure 4, where the target cell monitors the synchronization signals (e.g., primary synchronization signal, secondary synchronization signal, cell-specific signal) sent by the source cell directly to maintain synchronization with the source cell. The source cell is a cell providing synchronization for another cell and the target cell is a cell acquiring synchronization from another cell. When the target cell monitors the source cell, the target cell mutes its own transmission at least when the target cell and the source cell are in the same or the adjacent frequency. In order to achieve synchronization between multiple operators, some information such as the synchronization signals resource and the synchronous/asynchronous status should be friendly shared among different operators.



**Source cell**

**Target cell**

**Sync. Signal,**

**e.g. CRS**



Fig. 4 Air interface synchronization scheme

The target cell can synchronize to the arriving timing or the transmitting timing of the signals from the source cell. The following figure depicts one example of air interface synchronization scheme to achieve the transmitting timing alignment between the source cell and the target cell.



Fig. 5 Air interface synchronization scheme for multiple TDD operators in the same region

The procedure is as follows:

The target cell detects the primary synchronization signal sent by the source cell. The primary synchronization signal is used for timing for 5 ms frame;

The target cell detects secondary synchronization signal sent by the source cell. The secondary synchronization signal is used for timing for 5 ms frame and providing PCI information of the source cell;

The target cell sends a random access request. As a response to this signal, Timing Advancing (TA) will be sent by the source cell;

The target cell can finish the time synchronization procedure when TA is received.

* **Comparison among the above three schemes**

The advantages and disadvantages of the above three schemes are listed in the following table.

Table 1 Advantages and disadvantages of the above three schemes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Synchronization schemes** | **Advantages** | **Disadvantages** | **Application scenarios** | **Cost** |
| **GPS synchronization scheme** | * High synchronization accuracy; * Well-developed technique; | * Difficulties in antenna locating; * Hard to be implemented in indoor environment; * Low safety; | * Mainly used for outdoor base stations * Indoor base stations when GPS implementation is feasible | Low |
| **IEEE 1588v2 synchronization scheme** | * High safety; * High synchronization accuracy; * Implementation advantage compared with GPS; | * Require 1588v2; * Could not be used for asymmetric transmission systems such as ADSL; * Interface stability needs further verification; | * Mainly used for scenarios where GPS is hard to be implemented or GPS goes wrong; | Middle |
| **Air interface synchronization scheme** | * Currently, only solution for scenario where neither GPS nor IEEE 1588v2 could be utilized | * Currently under discussion in 3GPP; | * Mainly for home e-Node B and small cells; * Not suggested for synchronization between macro base stations; | - |

## 

## 4.3 Regulation

Synchronization scheme used to avoid interference could refer to consulted TDD frame setting solution in Section 4.1. For frequency management, interference due to un-synchronized transmission among operators should be consulted according to predefined process.

Two possible options are listed below.

**Option 1: Negotiation between operators**

(1) Operator A is interfered by operator B, and operator A has reasonable prof. Negotiation between operator A and operator B is preferred. In the case of negotiation failure, operator A could appeal to the Administration for the occurred interference. Relative prof should be proved at the same time.

(2) Once the Administration has its final judgment, operator B shall eliminate the interference to operator A, and reset its network to be synchronized in a given period.

**Option 2: Centralized information centre**

(1) A special information centre will be built to gather network information from each operator. The collected information may contain un-synchronized information, frame setting information, etc. The information centre works as an independent apartment or as a part of the Administration, and it will response only to the Administration.

(2) The Administration will notice the operator who is identified to be interfering other operators according to the alert information from information centre. The informed operator is requested to eliminate the interference within a given time period.

# Conclusion

Deployment of multiple TDD networks requires additional techniques or schemes to avoid interference among them. In order to avoid increase of equipment updating cost and to enhance spectrum utilization, using the predefined and agreed TDD frame settings among the operators is preferred. Furthermore, three synchronization techniques to achieve inter-operator synchronization are investigated as well. These techniques are “GPS synchronization scheme”, “IEEE 1588v2 synchronization scheme” and “Air interface synchronization scheme” and comparison among these schemes is made. Furthermore, synchronization management is discussed and two possible management implement schemes are presented.

**Annex**

**Summary of responses to Questionnaire on “NETWORK SYNCHRONIZATION TECHNOLOGIES IN RADIO ACCESS NETWORKS FOR IMT”**

**Question 1:** What cellular technologies are currently operated or planned to be operated that employ radio access network synchronization? (or what cellular technologies’ equipment are currently implemented or planned to be implemented that employ radio access network synchronization?)

**Answer**

| **Respondent** | **Cellular technologies** | **Frequency bands (MHz)** | **Status** | |
| --- | --- | --- | --- | --- |
| **Currently**  **operated/**  **implemented** | **Planned to be**  **operated/**  **implemented** |
| Bangladesh | GSM | 900, 1 800, 2 100 | √ |  |
| CDMA | 450, 800, 1 900 | √ |  |
| HSPA | 2 100 | √ |  |
| Malaysia | GSM | 900, 1 800 | √ |  |
| WCDMA | 900, 2 100 | √ |  |
| HSPA | 900, 2 100 | √ |  |
| HSPA+ | 900, 2 100 | √ |  |
| DC-HSPA | 2 100 | √ |  |
| LTE (FDD) | 1 800, 2 600 | √ |  |
| Singapore | GSM | 900, 1 800 | √ |  |
| UMTS | 900 | √ |  |
| WCDMA/HSPA+ | 2 100 | √ |  |
| LTE (FDD) | 1 800, 2 600 | √ |  |
| Sri Lanka | GSM | 900, 1 800 | √ |  |
| CDMA2000 | 450, 850 | √ |  |
| WCDMA | 2 100 (Band 1) | √ |  |
| HSPA+ | 2 100 (Band 1) | √ |  |
| LTE(FDD) | 1 800 (Band 3) | √ |  |
| LTE(TDD) | 2 300 (Band 40) | √ |  |
| Thailand | GSM | 900, 1 800 | √ |  |
| HSPA | 850, 900, 2 100 | √ |  |
| LTE(FDD) | 2 100 | √ |  |
| LTE(TDD) | 900, 1 800, 2 300, 2 600 |  | √ |
| Vietnam | GSM | 880-915/925-960  1 710-1 785/1 805-1 880 | √ |  |
| WCDMA/HSPA | 1 920-1 980/2 110-2 170 | √ |  |
|  | 2 300-2 390 |  | √ |
|  | 2 500-2 570/2 620-2 690 |  | √ |
|  | 2 575-2 615 |  | √ |
| China Mobile Communications Corporation | LTE(TDD) | 2 575-2 635 | √ |  |
| LTE(TDD) | 2 320-2 370 | √ |  |
| China Telecommunications Corporation | LTE(TDD) | 2 635-2 655 | √ |  |
| China United Network Communications Corporation | LTE(TDD) | 2 555-2 575 | √ |  |
| LTE(TDD) | 2 300-2 320 | √ |  |
| KT Corporation  (Korea) | WiMAX | 2 300-2 360 | √ |  |
| AIS  (Thailand) | GSM | 900 | √ |  |
| WCDMA | 2 100 | √ |  |
| CAT Telecom (Thailand) | WCDMA, HSPA, HSPA+ | 850 | √ |  |
| TOT Public Company Limited  (Thailand) | WCDMA, HSPA+ | 2 100 | √ |  |
| Real Future Company Limited (Thailand) | WCDMA | 2 100 | √ |  |
| LTE(FDD) | 2 100 | √ |  |

**Question 2:** With regard to the technologies listed in Question 1, what types of network synchronization are employed?

**Answer**

| **Respondent** | **Cellular technologies** | **Frequency bands** | **Types of network synchronization** | | |
| --- | --- | --- | --- | --- | --- |
| **Limited local area network** | **Intra-operator self-network synchronization** | **Inter-operator networks’ synchronization** |
| Bangladesh | GSM | 900, 1 800, 2 100 |  | √ |  |
| CDMA | 450, 800, 1 900 |  | √ |  |
| Malaysia | GSM | 900, 1 800 |  | √ |  |
| WCDMA | 900, 2 100 |  | √ |  |
| HSPA | 900, 2 100 |  | √ |  |
| HSPA+ | 900, 2 100 |  | √ |  |
| DC-HSPA | 2 100 |  | √ |  |
| LTE (FDD) | 1 800, 2 600 |  | √ |  |
| Singapore | GSM | 900, 1 800 |  |  | √ |
| UMTS | 900 |  | √ |  |
| WCDMA/HSPA+ | 2 100 |  | √ |  |
| LTE (FDD) | 1 800, 2 600 |  | √ |  |
| Sri Lanka | GSM | 900, 1 800 |  | √ |  |
| CDMA2000 | 450, 850 |  | √ |  |
| WCDMA | 2100 (Band 1) |  | √ |  |
| HSPA+ | 2100 (Band 1) |  | √ |  |
| LTE(FDD) | 1800 (Band 3) |  | √ |  |
| LTE(TDD) | 2 300 (Band 40) |  | √ |  |
| Vietnam | GSM | 880-915/925-960  1 710-1 785/1 805-1 880 |  |  |  |
| WCDMA/HSPA | 1 920-1 980/2 110-2 170 |  |  |  |
| China Mobile Communications Corporation | LTE(TDD) | 2 575-2 635 |  | √ |  |
| LTE(TDD) | 2 320-2 370 |  | √ |  |
| China Telecommunications Corporation | LTE(TDD) | 2 635-2 655 |  | √ |  |
| China United Network Communications Corporation | LTE(TDD) | 2 555-2 575 |  | √ |  |
| LTE(TDD) | 2 300-2 320 |  | √ |  |
| KT Corporation  (Korea) | WiMAX | 2 300-2 360 |  | √ |  |
| AIS  (Thailand) | GSM | 900 | √ | √ |  |
| WCDMA | 2 100 | √ | √ |  |
| CAT Telecom (Thailand) | WCDMA, HSPA, HSPA+ | 850 |  | √ |  |
| TOT Public Company Limited (Thailand) | WCDMA, HSPA+ | 2 100 | √ |  |  |
| Real Future Company Limited (Thailand) | WCDMA | 2 100 |  | √ |  |
| LTE(FDD) | 2 100 |  | √ |  |

**Question 3:** With regard to the technologies listed in Question 1, what kinds of synchronization solutions are employed?

**Answer**

| **Respondent** | **Cellular technologies** | **Frequency bands** | **Synchronization** | | |
| --- | --- | --- | --- | --- | --- |
| **GPS** | **Ethernet** | **Others** |
| Bangladesh | GSM | 900, 1 800, 2 100 | √ |  |  |
| CDMA | 450, 800, 1 900 | √ |  |  |
| Malaysia | GSM | 900, 1 800 | √ |  | TDM, IEEE1588v2, NTP |
| WCDMA | 900, 2 100 |  |  | TDM, IEEE1588v2, NTP |
| HSPA | 900, 2 100 |  |  | TDM, IEEE1588v2, NTP |
| HSPA+ | 900, 2 100 |  |  | TDM, IEEE1588v2, NTP |
| DC-HSPA | 2 100 |  |  | TDM, IEEE1588v2, NTP |
| LTE (FDD) | 1 800, 2 600 |  |  | IEEE1588v2, NTP |
| Singapore | GSM | 900, 1 800 | √ |  |  |
| UMTS | 900 | √ |  |  |
| WCDMA/HSPA+ | 2 100 | √ |  |  |
| LTE (FDD) | 1 800, 2 600 | √ |  |  |
| Sri Lanka | GSM | 900, 1 800 |  | √ | TDM E1 |
| CDMA2000 | 450, 850 | √ |  |  |
| WCDMA | 2 100 (Band 1) |  | √ | TDM E1 |
| HSPA+ | 2 100 (Band 1) |  | √ | TDM E1 |
| LTE(FDD) | 1 800 (Band 3) |  | √ |  |
| LTE(TDD) | 2 300 (Band 40) | √ |  |  |
| Vietnam | GSM | 880-915/925-960  1 710-1 785/1 805-1 880 |  |  | Mixed solutions |
| WCDMA/HSPA | 1 920-1 980/2 110-2 170 |  |  | Mixed solutions |
| China Mobile Communications Corporation | LTE(TDD) | 2 575-2 635 | √ | √ |  |
| LTE(TDD) | 2 320-2 370 | √ | √ |  |
| China Telecommunications Corporation | LTE(TDD) | 2 635-2 655 | √ | √ |  |
| China United Network Communications Corporation | LTE(TDD) | 2 555-2 575 | √ | √ |  |
| LTE(TDD) | 2 300-2 320 | √ | √ |  |
| KT Corporation  (Korea) | WiMAX | 2 300-2 360 | √ |  |  |
| AIS  (Thailand) | GSM | 900 |  | √ |  |
| WCDMA | 2 100 |  | √ |  |
| CAT Telecom (Thailand) | WCDMA, HSPA, HSPA+ | 850 |  | √ | IEEE 1588v2 |
| TOT Public Company Limited  (Thailand) | WCDMA, HSPA+ | 2 100 |  | √ |  |
| Real Future Company Limited (Thailand) | WCDMA | 2 100 |  | √ | Reference source from Cesuim and GPS |
| LTE(FDD) | 2 100 |  | √ | Reference source from Cesuim and GPS |

**Question 4:** What are your main technical and operational concerns when deploying radio access network synchronizations?

**Answer**

| **Respondent** | **Main technical and operational concerns** | | | |
| --- | --- | --- | --- | --- |
| **Cost** | **Precision of synchronization** | **Deployment scenarios** | **Other concerns** |
| Bangladesh |  | √ |  |  |
| Malaysia |  |  |  | NOTE (1) |
| Singapore | √ | √ |  |  |
| Sri Lanka | √  NOTE (2) | √  NOTE (3) |  |  |
| China Mobile Communications Corporation |  | √ | √ |  |
| China Telecommunications Corporation |  | √ | √ |  |
| China United Network Communications Corporation |  |  | √ NOTE (4) |  |
| KT Corporation  (Korea) |  | √ |  |  |
| AIS  (Thailand) |  | √ |  |  |
| CAT Telecom (Thailand) |  | √ |  |  |
| TOT Public Company Limited (Thailand) |  | √ |  |  |
| Real Future Company Limited (Thailand) | √ | √ |  |  |

NOTE

1. Synchronization technology evaluation still in development stage. For instance, few years back synchronous Ethernet was not able to handle phase synchronization.
2. First priority is for technical solution but cost is also optimized.
3. Standard requirements are always met.
4. The specific synchronization solutions need to be improved to meeting the requirement of the specific scenarios in one operator，especially those scenarios that could not deploy GPS in which some of the current solutions(eg.1588v2) still have precision problems.

**Question 5:** What are the levels of synchronization demands that you considered the most important?

**Answer**

| **Respondent** | **Levels of synchronization demands that you considered the most important** | | | |
| --- | --- | --- | --- | --- |
| **Limited local area network** | **Intra-operator self-network synchronization** | **Inter-operator networks’ synchronization** | **Others** |
| Bangladesh |  | √ |  |  |
| Malaysia |  | √ | √ |  |
| Singapore |  | √ | √ |  |
| Sri Lanka |  | √ | NOTE (1) |  |
| China Mobile Communications Corporation |  |  | √ |  |
| China Telecommunications Corporation |  |  | √ |  |
| China United Network Communications Corporation |  | √  NOTE (2) |  |  |
| KT Corporation  (Korea) |  | √ |  |  |
| AIS (Thailand) | √ |  |  |  |
| CAT Telecom (Thailand) |  | √ |  |  |
| TOT Public Company Limited  (Thailand) |  |  | √ |  |
| Real Future Company Limited (Thailand) |  | √ |  | PRS Ref. to G.811, IEE1588v2 |

NOTE

1. Becoming less relevant with IP transformation.
2. It is a fundamental problem. The synchronization of inter-operator networks will be no problem when intra-operator network perfectly synchronized and different operators' TDD networks in the same geographic area have the same time slot configuration.

**Question 6:** What are the requirements of synchronization solutions that you considered the most important?

**Answer**

| **Respondent** | **Requirements of synchronization solutions that you considered the most important** | | | |
| --- | --- | --- | --- | --- |
| **Easy to deploy** | **High precision** | **Specific scenarios** | **Others** |
| Bangladesh |  | √ |  |  |
| Malaysia | √ | √  NOTE (1) | √  NOTE (2) |  |
| Singapore |  | √ |  |  |
| Sri Lanka | √ | √ |  |  |
| China Mobile Communications Corporation |  | √ |  |  |
| China Telecommunications Corporation |  | √ |  |  |
| China United Network Communications Corporation |  |  | √  NOTE (3) |  |
| KT Corporation (Korea) | √ |  |  |  |
| AIS (Thailand) |  | √ |  |  |
| CAT Telecom (Thailand) |  | √ |  |  |
| TOT Public Company Limited (Thailand) |  | √ |  |  |
| Real Future Company Limited (Thailand) | √  Major requirement | √  Major requirement | √  Minor requirement |  |

NOTE

1. As long as can comply with the mobile access synchronization requirement/standard. Billing & exchanges would require high accuracy synchronization sources.
2. Flexibility to adapt with network changes and simplify operational (single design for multiple mobile access solution/supplier.
3. The reason is written in Question 4

**Question 7:** Are there any existing regulatory conditions and guidelines related to network synchronization in your country?

**Answer**

| **Respondent** | **Existing regulatory conditions and guidelines in your country** |
| --- | --- |
| Bangladesh | No. |
| Malaysia | As per international standard practice. |
| Singapore | No. |
| Sri Lanka | No. |
| Vietnam | TCVN 8073:2009 - Technical characteristic of Primary Clock |
| China Mobile Communications Corporation | CCSA TC5 WG8 has started the research on COEXISTENCE IN ADJACENT SPECTRUM BLOCKS IN TDD MODE AND POSSIBLE SPECTRUM MANAGEMENT SCHEME in Dec. 2013. |
| China Telecommunications Corporation | No. |
| KT Corporation  (Korea) | Regulatory guideline recommends that an agreement should be reached between operators to implement inter-operator network synchronization. |
| AIS (Thailand) | No. |
| Real Future Company Limited (Thailand) | ITU-T G.811, G.812 (applied for Primary Reference Source and Synchronization Supply Unit), IEEE 1588v2 (applied for UTRAN and IP based), TS25.402 (applied for UTRAN), and Coordinated Universal Time (UTC) (applied for IT and Billing System) |

**Question 8:** What is your expectation or suggestions for AWG’s studies on network synchronization technologies in radio access networks for IMT?

**Answer**

| **Respondent** | **Existing regulatory conditions and guidelines in your country** |
| --- | --- |
| Bangladesh | – |
| Malaysia | The recommendation derived from AWG’s studies is expected to facilitate the development of features that will avoid expensive packet synchronization solution and avoid operator to change the existing transport equipments. |
| Singapore | To study synchronisation technologies for co-channel usage by different operators in same geographical location. |
| Sri Lanka | It is timely to study synchronization distribution on IP transport network and recommend some architecture and guide lines which can be used in practice. |
| China Mobile Communications Corporation | In our application scenario, synchronization solutions for adjacent bands and also for different operators in intra band are requested. Thus, it would be very useful if corresponding solutions or specifications were released via researches in AWG. |
| TOT Public Company Limited  (Thailand) | The cost of high precision of synchronization network and how to lower it. |
| Real Future Company Limited (Thailand) | Role of the international and reference systems service for IMT. |

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1. http://apps.ero.dk/eccnews/april-2014/regulatory-framework.html [↑](#footnote-ref-1)