

## WTTx Capacity White Paper

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# About This Document

## Overview

Wireless to the x (WTTx) is continuously developing around the world. WTTx networks deployed in regions such as the Middle East (STC Saudi Arabia and Mobily Saudi Arabia), Southeast Asia (First Media Indonesia), and China (Jilin Mobile) are maturing. However, the growing demand of data services brings capacity challenges to WTTx networks. Congestion occurs on WTTx networks during busy hours, causing problems including network access failures and low service rates.

This document provides the LTE TDD WTTx network capacity monitoring guidelines and network resource insufficiency diagnosis methods for maintenance and network planning personnel to monitor various network resources in real time. The resource monitoring results can serve as a reference for network resource optimization and capacity expansion, preventing the network quality and user experience deterioration caused by insufficient resources.

This document provides only the method of monitoring LTE TDD WTTx network resources. The criteria for performing network capacity expansion must be customized and evaluated by Huawei Inventory management team.

### NOTE

1. For details about eNodeB MML commands, parameters, alarms, and performance counters mentioned in this document, see *3900 Series Base Station Product Documentation*.
2. Guidelines provided in this document do not apply to scenarios where a large amount of traffic volume is involved. Service guarantee for these scenarios requires the support of Huawei professional service.

## Product Version

The following table lists the product versions covered by this document.

Product	Version
DBS3900	V100R007C10
	V100R008C10
	V100R110C00
	V100R110C10

## Intended Audience

This document is intended for:

- Huawei field engineers
- Huawei network planning engineers
- Customers' network planning engineers

## Change History

This section describes the changes in each version of this document.

- 01 (2016-03-18)

This is the first official release.

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# 1 WTTx Network Capacity Overview

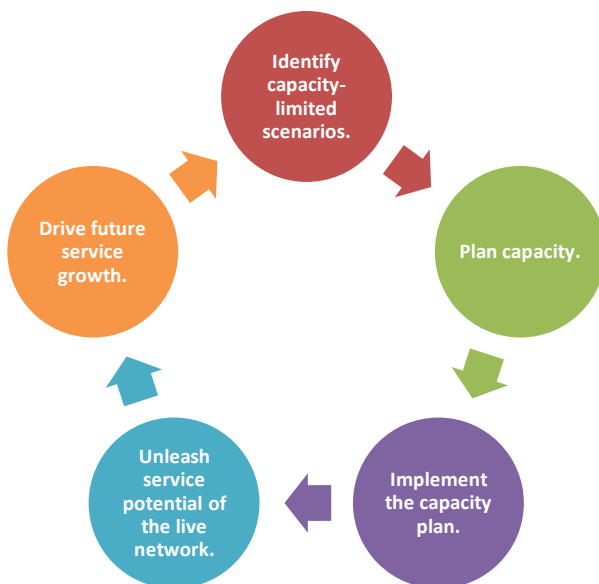
This chapter describes the overall capacity planning solution for WTTx networks.

## 1.1 Capacity Planning Panorama

Capacity of WTTx networks is planned based on capacity requirements of the live network and future service development. A proper phase-based deployment plan is designed based on operators' spectrum resources, equipment status, and service growth to ensure a steady growth of the user base, services, and revenue for operators.

Figure 1-1 shows the process of capacity planning for WTTx networks.

**Figure 1-1** Process of capacity planning for WTTx networks



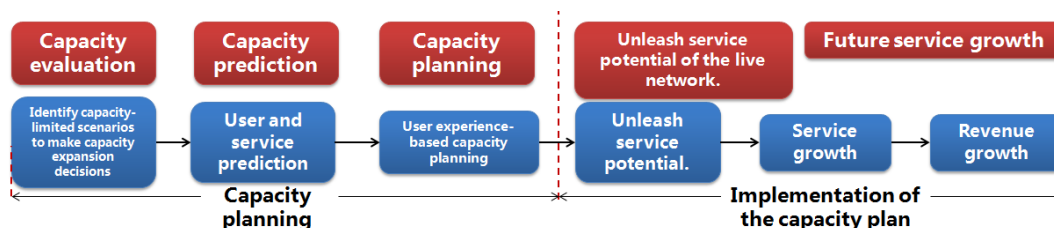
Capacity planning for WTTx networks is performed in an iterative process. A proper capacity plan is made based on user and service development in the foreseeable future predicted based on historical user and service development trends and operators' development strategies, to meet the demand of growing services. Routine capacity monitoring is performed during

service development to periodically adjust the capacity plan, ensuring that network capacity meet the demand of growing services.

## 1.2 Capacity Planning Methodology

Figure 1-2 shows the panorama of capacity planning for WTTx networks.

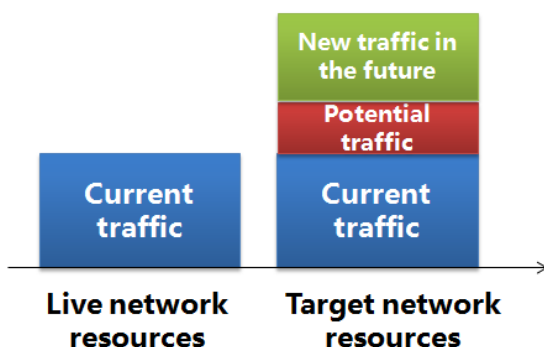
**Figure 1-2** Panorama of capacity planning for WTTx networks



- Prediction-based capacity planning:  
Network capacity is generally planned to meet the requirements of target networks in the foreseeable future based on the prediction of future user and service development, as well as to resolve congestion problems that occur on the live network. Therefore, current and future service requirements must be considered during capacity planning.
- Unleashing traffic potential for service growth:  
After a capacity plan is implemented, user and service potential of the live network can be unleashed, and network capacity can be expanded in phases to meet the requirements of the future growth of the user base and services.

Figure 1-3 shows the capacity planning for target WTTx networks and live network resources.

**Figure 1-3** Capacity planning for target WTTx networks and live network resources



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# 2 WTTx Network Capacity Planning

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This chapter describes the method of WTTx network capacity planning and the planning procedure.

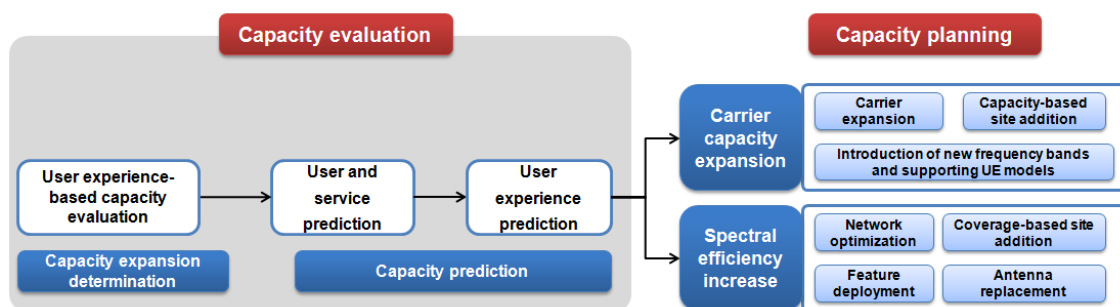
## 2.1 Capacity Expansion Overview

- Drive to capacity expansion  
User satisfaction, a specified percentage of satisfied users in certain scenarios, drives capacity expansion. If user satisfaction is lower than the specified percentage, network capacity must be expanded.
- Lever to achieve a balance  
The goal of capacity planning is to increase an operator's revenue by capacity expansion. The capacity expansion standard functions as a lever to turn user satisfaction into revenue and help achieve a balance between investment and revenue.
- Best capacity expansion standard  
The best capacity expansion standard is a methodology that ensures network performance and user experience and drive service growth with minimum investment and maximum revenue of operators.

## 2.2 Capacity Expansion Procedure

Figure 2-1 shows the capacity planning procedure for WTTx networks.



**Figure 2-1** Capacity planning procedure for WTTx networks**Capacity Evaluation and Planning Procedure for LTE TDD Networks**

## 2.3 Capacity Expansion Standard

The user experience-based capacity expansion standard is formulated using the Erl-B planning method for voice services according to the "Poisson process" theory.

User experience-based capacity expansion standard is as follows:

- UEs access networks for services randomly and independently on an equal probability basis. The probability of  $k$  UEs performing services at the same time complies with the Poisson distribution.

$$P(k) = \frac{\lambda^k}{k!} e^{-\lambda}, \quad k = 0, 1, \dots$$

- A fully loaded cell has transmission rate of  $Y$  (Mbit/s). The user experience rate decreases as the number of UEs increases.
- To ensure that the user experience rate is not lower than  $X$  Mbit/s, the number of UEs transmitting data must be less than  $Z$ , which equals  $Y$  divided by  $X$ .
- To ensure that user satisfaction is higher than 90% [ $P(k \leq Z) \geq 90\%$ ], use the threshold of the average number of UEs transmitting data  $\lambda$  calculated by the Poisson process formula as the capacity expansion threshold.

$$P(k \leq Z) = P(k = 0) + P(k = 1) + \dots + P(k = Z) = \sum_{k=0}^Z \frac{\lambda^k}{k!} e^{-\lambda} \geq 90\%$$

### 2.3.1 Capacity Expansion Threshold for Typical Service Models

Typical service models are summarized based on the top 10 LTE TDD WTTx networks in the world. The characteristics of such service models are as follows:

- The transmission rate of a fully loaded cell is ranges from 15 Mbit/s to 40 Mbit/s.
- The user guaranteed rate is ranges from 2 Mbit/s to 8 Mbit/s.
- The lowest user satisfaction rate that meets requirement is 90%.
- The UE duty rate is 15% (for WTTx data services).
- The spectrum bandwidth of ordinary single carrier is 20 MHz.

The average number of UEs in RRC\_CONNECTED mode is used as the capacity expansion threshold.

Table 2-1 lists capacity expansion thresholds calculated for the preceding service models.

You can obtain the threshold of the average number of UEs in RRC\_CONNECTED mode in Table 2-1 based on the full-load cell transmission rate and user guaranteed rate.

**Table 2-1** Capacity expansion threshold (the average number of UEs in RRC\_CONNECTED mode) for typical service models

Capacity Expansion Threshold		Full-Load Cell Transmission Rate					
		15	20	25	30	35	40
User Guaranteed Rate	2	36	47	58	74	85	103
	3	21	26	36	47	52	63
	5	12	16	21	26	31	36
	8	4	7	12	14	16	21

For example, if the full-load cell transmission rate is 30 Mbit/s and the user guaranteed rate is 3 Mbit/s, the capacity expansion threshold (threshold of the average number of UEs in RRC\_CONNECTED mode) is 47.

## 2.3.2 Calculation of the User Experience-based Capacity Expansion Standard

### Scenario

- UE access  
UEs access networks for services randomly and independently on an equal probability basis. The probability of  $k$  UEs accessing the network at the same time in a measurement period complies with the Poisson distribution. The probability of  $k$  UEs accessing the network at the same time can be calculated using the following formula:

$$P(k) = \frac{\lambda^k}{k!} e^{-\lambda}, \quad k = 0, 1, \dots$$

- User guaranteed rate  $X$  (Mbit/s)

Indicator source: service models

The user guaranteed rate can be set based on service or operator requirements. It is recommended that  $X$  be set to a value greater than or equal to 5. A customer network is used as an example:

$\text{Single-UE guaranteed rate} = \frac{\sum(\text{Guaranteed rate of service } i \times \text{Concurrence rate of service } i)}{\text{Number of concurrent services per UE during busy hours}}$
--

Benchmark (HW MBB Lab)			China Mobile Networks in City D	
Service Type	Benchmark User Guaranteed Rate (Mbit/s)	Number of Concurrent Services Per UE During Busy Hours	Service Concurrency Rate (Duration Proportion)	User Guaranteed Rate (Mbit/s)
Web browsing	2.5	1.36	54%	1.84
IM	0.256		5%	0.02
SNS	2.5		2%	0.07
Streaming	6		23%	1.88
File transfer	10		11%	1.50
Email	3		1%	0.04
Gaming	0.512		1%	0.01
Others	3		2%	0.08
<b>Total</b>			100%	<b>5.44</b>

- Full-load cell transmission rate  $Y$  (Mbit/s)

Indicator source: performance counter

The full-load cell transmission rate is the transmission rate that a cell can provide when multiple UEs are evenly distributed in the cell and the PRB usage of the cell reaches 100%

$$Y = \frac{\text{Average cell throughput}}{\text{PRB used rate}} \times 100\%$$

The following table lists typical values of the full-load cell transmission rate in different networking modes (with a CQI no less than 9).

CPE \ eNodeB		2T2R	4T4R	8T8R	8T8R (Soft Split)	64T (Massive MIMO)
		Indoor	2R	25	28.75	40
4R	35	45	62.4	66.3	225 – 300	
Outdoor	2R	35	40.25	48.3	53.2	210 – 280
4R	49	63	75.6	83.16	315 – 420	

- Maximum number of UEs transmitting data  $Z$

Indicator source: performance counter

If the number of UEs transmitting data exceeds  $Z$  and the single-UE rate is lower than  $X$  Mbit/s, user experience does not meet preset requirements.

$$Z = \frac{Y}{X}$$

- User satisfaction rate  $P$  (%)

Indicator source: operators

User satisfaction is the proportion of the UEs that have a user experience rate greater than  $X$  Mbit/s in a measurement period. It is recommended that the user satisfaction threshold be set to 90% or 95%. The user satisfaction threshold can be set based on regional or scenario requirements. For example, it can be set to 95% for urban areas and 90% for rural areas.

- Threshold of the average number of UEs transmitting data  $Q$

Indicator source: calculated using the preceding indicators

The threshold of the average number of UEs transmitting data is the Poisson process mean value  $Q$  obtained when the probability of the user experience rate equal to or higher than  $X$  Mbit/s (that is, the number of UEs transmitting data is smaller than or equals to  $Z$ ) is equal to or higher than  $P\%$ .

$$P(k \leq Z) \geq 90\%$$

$$P(k \leq Z) = P(k = 0) + P(k = 1) + \dots + P(k = Z) = \sum_{k=0}^Z \frac{Q^k}{k!} e^{-Q} \geq 90\%$$

- UE quantity-related indicators  
Table 2-2 lists typical UE quantity-related indicators.

**Table 2-2** UE quantity-related indicators

Name	Formula	Type	Source
UE duty rate	Number of UEs transmitting data/Average number of UEs in RRC_CONNECTED mode	Cell-, region-, and network-level	Number of UEs transmitting data: performance counter Average number of UEs in RRC_CONNECTED mode: performance counter Number of registered UEs: HSS Number of UEs with allocated numbers: operator data
UE active rate	Average number of UEs in RRC_CONNECTED mode/Number of registered UEs	Region- and network-level	
UE attachment rate	Number of registered UEs/Number of UEs with allocated numbers	Region- and network-level	
UE active rate with allocated numbers	Number of UEs transmitting data/Number of UEs with allocated numbers	Region- and network-level	

**Table 2-3** Typical values of UE quantity-related indicators

Name	Typical Value		
	Jilin Mobile	STC KSA	Ooredoo Oman
UE duty rate	13%	17%	15%
UE active rate (during busy hours)	30%	40%	35%
UE attachment rate	80%	90%	88%
UE active rate with allocated numbers (during busy hours)	3.1%	6%	4.6%

## 2.3.3 Examples of Calculating the Capacity Expansion Threshold

### 2.3.3.1 Traditional Capacity Expansion Scenario (Hybrid Service Scenario)

#### Input

- The full-load cell transmission rate  $Y$  is 30 Mbit/s.
- The user guaranteed rate  $X$  is 5 Mbit/s.

- The user satisfaction rate  $P$  is 90%.
- The UE duty rate is 15%.
- The UE active rate is 30%.
- The UE attach rate is 90%.

The preceding items and the following formulas are used to calculate the threshold of the average number of UEs performing data transmission  $Q$  (the capacity expansion threshold).

$$P\% \leq \sum_{k=0}^z \frac{Q^k}{k!} e^{-Q}$$

$$90\% \leq \sum_{k=0}^{k=30/5} \frac{Q^k}{k!} e^{-Q}$$

## Calculation

- Tool: Microsoft Excel
- Function: POISSON(k,mean,cumulative)
- Calculation method
  - $K$  indicates the maximum number of UEs performing data transmission. It is a known input value.
  - Set *cumulative* to *True*.
  - Use the method of exhaustion and Microsoft Excel to calculate  $Q$  when the result of POISSON( $k, Q, TRUE$ ) is greater than or equal to 90%.

The POISSON function has the following parameters:  
 $K$ : Indicates the number of events and is mandatory.  
 $Q$ : Indicates the expected value and is mandatory.  
*cumulative*: Indicates the type of the returned probability distribution. It is a logical value and is mandatory. If *cumulative* is set to *TRUE*, the POISSON function returns the cumulative Poisson probability for the number of random events ranging from 0 to  $x$ . If *cumulative* is set to *FALSE*, the POISSON function returns the Poisson probability density function for the number of random events  $x$ .

## Calculation Results

- $Q = 3.89$
- Threshold of the average number of UEs in RRC\_CONNECTED mode =  $3.89/15\% = 26$
- Threshold of the number of UEs with allocated numbers =  $25.9/30\%/90\% = 96$

To ensure that the user experience rate is greater than or equals to 5 Mbit/s in 90% of time or more:

- Expand cell capacity when the average number of UEs in RRC\_CONNECTED mode exceeds 26.
- The cell should be capable of providing services for up to 96 UEs with allocated numbers.

The application scenarios of the calculated thresholds are as follows:

- Use the threshold of the average number of UEs in RRC\_CONNECTED mode to determine whether to expand capacity for live networks.

- Use the threshold of the number of UEs with allocated number to determine whether to expand capacity to meet future service requirements.

### 2.3.3.2 Video Service Scenario

#### Input

- The full-load cell transmission rate  $Y$  is 30 Mbit/s.
- The user guaranteed rate  $X$  is 5 Mbit/s. (For 720p videos, the video buffering rate is 5 Mbit/s and the playing rate is 2 – 3 Mbit/s. The user guaranteed rate is set based on the maximum service requirement.)
- The user satisfaction rate  $P$  is 90%.
- The UE duty rate is 30%. (UEs do not transmit data when playing videos. The duty cycle of video UEs does not reach 100%.)
- The UE active rate is 50%.
- The UE attach rate is 90%.

The preceding items and the following formulas are used to calculate the threshold of the average number of UEs performing data transmission  $Q$  (the capacity expansion threshold).

$$P\% \leq \sum_{k=0}^Z \frac{Q^k}{k!} e^{-Q}$$

$$90\% \leq \sum_{k=0}^{k=30/5} \frac{Q^k}{k!} e^{-Q}$$

#### Calculation Results

- $Q = 3.89$
- Threshold of the average number of UEs in RRC\_CONNECTED mode =  $3.89/30\% = 13$
- Threshold of the number of UEs with allocated numbers =  $13/50\%/90\% = 29$

To ensure that users are satisfied about 720p video services in 90% of time or more:

- Expand cell capacity when the average number of UEs in RRC\_CONNECTED mode exceeds 13.
- The cell should be capable of providing services for up to 29 UEs with allocated numbers.

The application scenarios of the calculated thresholds are as follows:

- Use the threshold of the average number of UEs in RRC\_CONNECTED mode to determine whether to expand capacity for live networks.
- Use the threshold of the number of UEs with allocated number to determine whether to expand capacity to meet future service requirements.

### 2.3.4 Capacity Expansion Threshold for Differentiated Scenarios

The capacity expansion criteria involve the full-load cell transmission rate  $Y$  (Mbit/s), user guaranteed rate  $X$  (Mbit/s), user satisfaction rate  $P$  (%), UE duty rate  $R$  (%), UE active rate  $S$  (%), and UE attachment rate  $T$  (%). These input items are different between service scenarios, networks, regions, and cells. You can obtain the threshold of the average number of UEs transmitting data in Table 2-4 and calculate the threshold of the average number of UEs in

RRC\_CONNECTED mode and threshold of the number of UEs with allocated numbers based on UE quantity-related counters.

Input items:

- Full-load cell transmission rate  $Y$  (Mbit/s)
- User guaranteed rate  $X$  (Mbit/s)
- User satisfaction rate  $P$  (%)

**Table 2-4** Threshold of the average number of UEs transmitting data for differentiated scenarios

Full-Load Cell Transmission Rate (Mbit/s)	User Guaranteed Rate (Mbit/s)	User Satisfaction Rate				
		90%	80%	70%	60%	50%
15	2	5.43	6.43	7.22	7.95	8.67
	3	3.15	3.9	4.52	5.09	5.67
	5	1.74	2.3	2.76	3.21	3.67
	8	0.53	0.82	1.1	1.38	1.68
20	2	7.02	8.16	9.05	9.86	10.67
	3	3.89	4.73	5.41	6.04	6.67
	5	2.43	3.09	3.63	4.15	4.67
	8	1.1	1.53	1.91	2.28	2.67
25	2	8.64	9.91	10.9	11.79	12.67
	3	5.43	6.43	7.22	7.95	8.67
	5	3.15	3.9	4.52	5.09	5.67
	8	1.74	2.3	2.76	3.21	3.67
30	2	11.14	12.57	13.69	14.69	15.67
	3	7.02	8.16	9.05	9.86	10.67
	5	3.89	4.73	5.41	6.04	6.67
	8	2.04	3.1	3.195	3.68	4.17
35	2	12.82	14.37	15.56	16.63	17.67
	3	7.83	9.03	9.97	10.83	11.67
	5	4.66	5.58	6.31	6.99	7.67
	8	2.43	3.09	3.63	4.15	4.67
40	2	15.38	17.08	18.38	19.54	20.67
	3	9.47	10.79	11.82	12.75	13.67
	5	5.43	6.43	7.22	7.95	8.67
	8	3.15	3.9	4.52	5.09	5.67

# 3 Appendix

This chapter describes all counters involved in system resource monitoring.

## 3.1 Counter Overview

Table 3-1 lists counters involved in capacity planning.

**Table 3-1** Counters involved in capacity planning

Type	Counter	Description
PRB resources	L.ChMeas.PRB.UL.Used.Avg	Average number of used uplink PRBs
	L.ChMeas.PRB.UL.Avail	Number of available uplink PRBs
	L.ChMeas.PRB.DL.Used.Avg	Average number of used downlink PRBs
	L.ChMeas.PRB.DL.Avail	Number of available downlink PRBs
Data transmission	L.Thrp.bits.DL	Total downlink throughput at the PDCP layer in a cell
	L.Thrp.Time.DL	Total duration for transmitting downlink data at the PDCP layer in a cell
	L.Thrp.bits.UL	Total uplink throughput at the PDCP layer in a cell
	L.Thrp.Time.UL	Total duration for transmitting uplink data at the PDCP layer in a cell
User quantity	L.Traffic.User.Avg	Average number of UEs in a cell/Average number of UEs in RRC_CONNECTED mode
	L.Traffic.User.Max	Maximum number of UEs in a cell
	L.Traffic.ActiveUser.DL.Avg	Average number of active UEs in the downlink
UE quantity proportion	UE duty rate	Proportion of the number of UEs transmitting data to the number of UEs in RRC_CONNECTED mode



	UE active rate	Proportion of the number of UEs in RRC_CONNECTED mode to the number of registered UEs
	UE attachment rate	Proportion of the number of registered UEs to the number of UEs with allocated numbers
	UE active rate with allocated numbers	Proportion of the number of UEs transmitting data to the number of UEs with allocated numbers

Table 3-2 lists the formulas of calculating capacity-related counters.

**Table 3-2** Formulas of calculating capacity-related counters

Description	Formula
Downlink traffic (MB)	$L.Thrp.bits.DL/1024/1024/8$
Downlink PRB usage	$L.ChMeas.PRB.DL.Used.Avg/L.ChMeas.PRB.DL.Avail$
Downlink cell rate (Mbit/s)	$L.Thrp.bits.DL/1024/1024/(L.Thrp.Time.Cell.DL.HighPrecision/1000/Downlink\ coefficient)$
Downlink full-load cell transmission rate (Mbit/s)	$L.Thrp.bits.DL/1024/1024/3600/(L.ChMeas.PRB.DL.DrbUsed.Avg/L.ChMeas.PRB.DL.Avail)$
Downlink user rate (Mbit/s)	$L.Thrp.bits.DL/1024/1024/L.Thrp.Time.DL \times 1000$
Number of UEs performing data transmission	$L.Thrp.Time.DL/(L.Thrp.Time.Cell.DL.HighPrecision/Downlink\ coefficient)$
Uplink traffic (MB)	$L.Thrp.bits.UL/1024/1024/8$
Uplink PRB usage	$L.ChMeas.PRB.UL.Used.Avg/L.ChMeas.PRB.UL.Avail$
Uplink cell rate (Mbit/s)	$L.Thrp.bits.UL/1024/1024/(L.Thrp.Time.Cell.UL.HighPrecision/1000/Uplink\ coefficient)$
Uplink full-load cell transmission rate (Mbit/s)	$L.Thrp.bits.UL/1024/1024/3600/(L.ChMeas.PRB.UL.DrbUsed.Avg / L.ChMeas.PRB.UL.Avail)$
Uplink user rate (Mbit/s)	$L.Thrp.bits.UL/1024/1024/L.Thrp.Time.UL \times 1000 \times Uplink\ coefficient$
Number of UEs transmitting data in the uplink	$L.Thrp.Time.UL/(L.Thrp.Time.Cell.UL.HighPrecision/Uplink\ coefficient)$



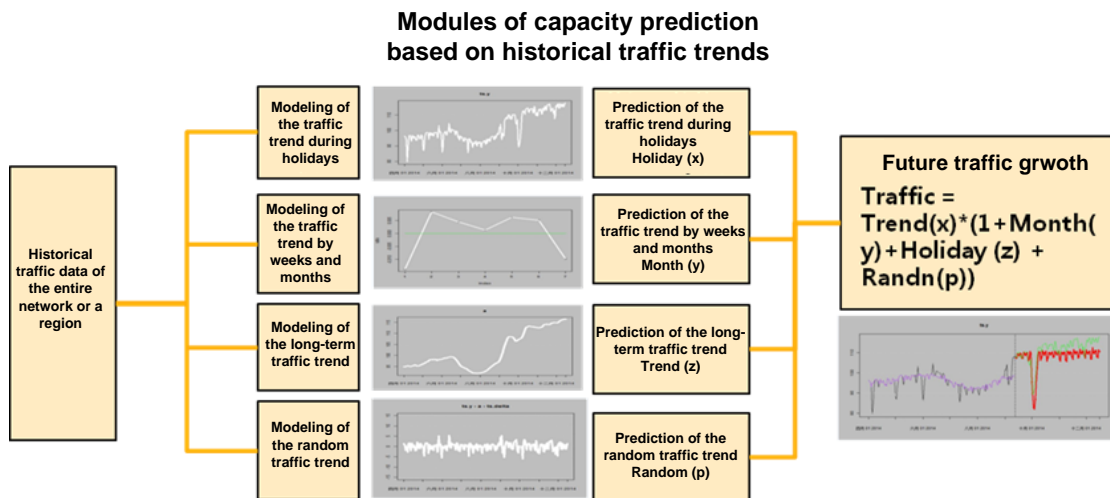
**NOTE**

The uplink/downlink coefficient is calculated based on the uplink-downlink subframe configuration and special subframe configuration. For example, for the uplink-downlink subframe configuration 2 and special subframe configuration 5, the uplink coefficient is 1/5 and the downlink coefficient is 3/5.

## 3.2 Traffic Prediction Method

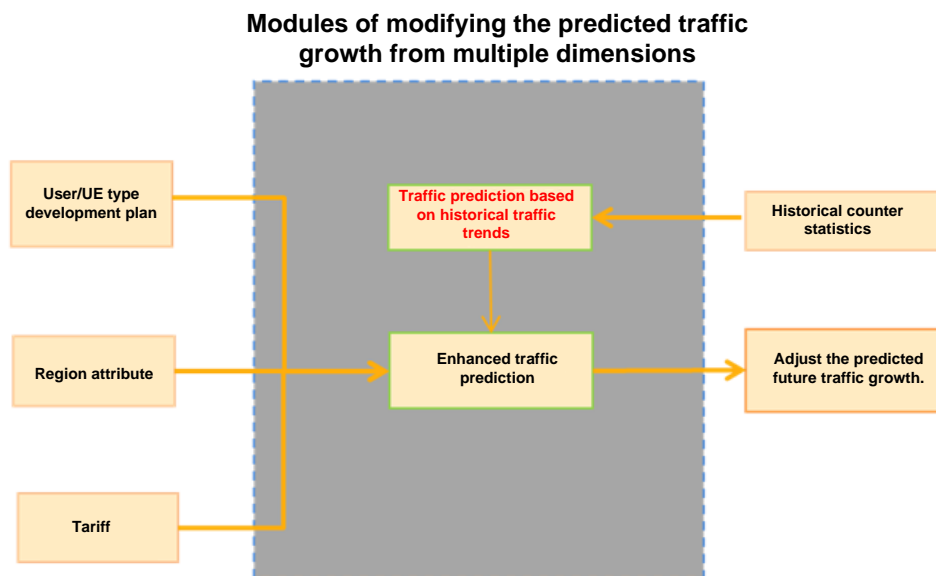
- Step 1** Create traffic trends from historical traffic data in a certain period. Analyze the traffic trend during holidays, by weeks and months, in a long term, and the random traffic trend.
- Step 2** Summarize the overall traffic trend. Use the summarized rules to predict traffic volumes of different dimensions and use these traffic volumes to predict the total traffic volume.

**Figure 3-1** Procedure for traffic prediction based on historical traffic trends



**Step 3** Modify the predicted traffic growth based on historical prediction results and the user/UE type development plans of operators.

**Figure 3-2** Procedure for modifying the predicted traffic growth from multiple dimensions



The traffic prediction algorithm is added to iDart since WINS V001R008C300. You can visit <http://support.huawei.com> to obtain iDart of this version and its operation guide.

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