    Label Switched Path (LSP) Data Path Delay Metric in Generalized MPLS/
                             MPLS-TE Networks
                       draft-sun-ccamp-dpm-01.txt

Abstract

   When setting up a label switched path (LSP) in Generalized MPLS and
   MPLS/TE networks, the completion of the signaling process does not
   necessarily mean that the cross connection along the LSP have been
   programmed accordingly and in a timely manner. Meanwhile, the
   completion of signaling process may be used by applications as
   indication that data path has become usable. The existence of this
   delay and the possible failure of cross connection programming, if
   not properly treated, will result in data loss or even application
   failure. Characterization of this performance can thus help
   designers to improve the application model and to build more robust
   applications. This document defines a series of performance metrics
   to evaluate the availability of data path in the signaling process.

Table of Contents

1. Introduction

Ideally, the completion of the signaling process means that the
signaled label switched path (LSP) is available and is ready to carry
traffic. However, in actual implementations, vendors may choose to
program the cross connection in a pipelined manner, so that the
overall LSP provisioning delay can be reduced. In such situations,
the data path may not be available instantly after the signaling
process completes. Implementation deficiency may also cause the
inconsistency in between the signaling process and data path
provisioning. For example, if the data plane failed to program the
cross connection accordingly but does not manage to report this to
the control plane, the signaling process may complete successfully
while the corresponding data path will never become functional at
all.

On the other hand, the completion of the signaling process may be
used in many cases as indication of data path availability. For
example, when invoking through User Network Interface (UNI), a client
device or an application may use the reception of the correct RESV
message as indication that data path is fully functional and start to
transmit traffic. This will results in data loss or even application
failure.

Although RSVP(-TE) specifications have suggested that the cross
connections are programmed before signaling messages are propagated
upstream, it is still worthwhile to verify the conformance of an
implementation and measure the delay, when necessary.

This document defines a series of performance metrics to evaluate the
availability of data path when the signaling process completes. The
metrics defined in this document complements the control plane
metrics defined in [I-D.ietf-ccamp-lsp-dppm]. They can be used to
verify the conformance of implementations against related
specifications, as elaborated in
[I-D.shiomoto-ccamp-switch-programming]. They also can be used to
build more robust applications.

2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in [RFC2119].

3. Overview of Performance Metrics

   In this memo, we define three performance metrics to characterize the
   performance of data path provisioning with GMPLS/MPLS-TE signaling.
   These metrics complement the metrics defined in
   [I-D.ietf-ccamp-lsp-dppm], in the sense that the completion of the
   signaling process for a Label Switched Path (LSP) and the programming
   of cross connections along the LSP may not be consistent. The
   performance metrics in [I-D.ietf-ccamp-lsp-dppm] characterize the
   performance of LSP provisioning from the pure signaling point of
   view, while the metric in this document takes into account the
   validity of the data path.

   The three metrics are:

   o RRFD - the delay between RESV message received by ingress node and
      forward data path becomes available.

   o RSRD - the delay between RESV message sent by egress node and
      reverse data path becomes available.

   o PRFD - the delay between PATH message received by egress node and
      forward data path becomes available.

   As in [I-D.ietf-ccamp-lsp-dppm], we continue to use the structures
   and notions introduced and discussed in the IPPM Framework document,
   [RFC2330] [RFC2679] [RFC2681]. The reader is assumed to be familiar
   with the notions in those documents. The readers are assumed to be
   familiar with the definitions in [I-D.ietf-ccamp-lsp-dppm] as well.

4. Terms used in this document

   o Forward data path - the data path from the ingress to the egress.
      Instances of forward data path include the data path of a uni-
      directional LSP and data path from the ingress node to the egress
      node in a bidirectional LSP.

   o Reverse data path - the data path from the egress to the ingress
      in a bidirectional LSP.

   o Error free signal - data plane specific indication of availability
      of the data path. For example, for packet switched interfaces,
      the reception of the first error free packet from one side of the
      LSP to the other can be used as the error free signal. For SDH/
      SONET cross connects, the disappearance of alarm can be used as
      the error free signal. Through out this document, we will use the
      "error free signal" as a general term. An implementations must
      choose a proper data path signal that is specific to the data path
      technology being tested.

   o Ingress/egress node - in this memo, an ingress/egress node means a
      measurement endpoint with both control plane and data plane
      features. Typically, the control plane part on an ingress/egress
      node interact with the control plane of the network under test.
      The data plane part of an ingress/egress node will generate data
      path signals and send the signal to the data plane of the network
      under test, or receive data path signals from the network under
      test.

5. A singleton Definition for RRFD

   This part defines a metric for forward data path delay when an LSP is
   setup.

   As described in [I-D.shiomoto-ccamp-switch-programming], the
   completion of the RSVP-TE signaling process does not necessarily mean
   that the cross connections along the LSP being setup are in place and
   ready to carry traffic. This metric defines the time difference
   between the reception of RESV message by the ingress node and the
   completion of the cross connection programming along the forward data
   path.

5.1. Motivation

   RRFD is useful for several reasons:

   o For the reasons described in
      [I-D.shiomoto-ccamp-switch-programming], the data path may not be
      available instantly after the completion of the RSVP-TE signaling
      process. The delay itself is part of the implementation
      performance.

   o The completion of the signaling process may be used by application
      designers as indication of data path availability. The existence
      of this delay and the potential failure of cross connection
      programming, if not properly treated, will result in data loss or
      application failure. The typical value of this delay can thus
      help designers to improve the application model.

5.2. Metric Name

   RRFD

5.3. Metric Parameters

   o ID0, the ingress LSR ID

   o ID1, the egress LSR ID

   o T, a time when the setup is attempted

5.4. Metric Units

   Either a real number of milli-seconds or undefined.

5.5. Definition

For a real number dT, RRFD from ingress node ID0 to egress node ID1
at T is dT means that ingress node ID0 send a PATH message to egress
node ID1 and the last bit of the corresponding RESV message is
received by ingress node ID0 at T, and an error free signal is
received by egress node ID1 by using a data plane specific test
pattern at T+dT.

5.6. Discussion

The following issues are likely to come up in practice:

o The accuracy of RRFD depends on the clock resolution of both the
   ingress node and egress node. Clock synchronization between the
   ingress node and egress node is required.

o The accuracy of RRFD is also dependent on how the error free
   signal is received and may differ significantly when the underline
   data plane technology is different. For instance, for an LSP
   between a pair of Ethernet interfaces, the ingress node (sometimes
   the tester) may use a rate based method to verify the availability
   of the data path and use the reception of the first error free
   frame as the error free signal. In this case, the interval
   between two successive frames has a significant impact on
   accuracy. It is RECOMMENDED that the ingress node uses small
   intervals, under the condition that the injected traffic does not
   exceed the capacity of the forward data path. The value of the
   interval MUST be reported.

o The accuracy of RRFD is also dependent on the time needed to
   propagate the error free signal from the ingress node to the
   egress node. A typical value of propagating the error free signal
   from the ingress node to the egress node under the same
   measurement setup MAY be reported. The methodology to obtain such
   values is outside the scope of this document.

o It is possible that under some implementations, a node may program
   the cross connection before it sends PATH message further
   downstream and the data path may be available before a RESV
   message reaches the ingress node. In such cases, RRFD can be a
   negetive value. It is RECOMMENDED that PRFD measurement is
   carried out to further characterize the forward data path delay
   when a negetive RRFD value is observed.

o If error free signal is received by the egress node before PATH
   message is sent, an error MUST be reported and the measurement
   SHOULD terminate.

o If the corresponding RESV message is received, but no error free
   signal is received by the egress node within a reasonable period
   of time, RRFD MUST be treated as undefined. The value of the
   threshold MUST be reported.

o If the LSP setup fails, RRFD MUST NOT be counted.

5.7. Methodologies

Generally the methodology would proceed as follows:

o Make sure that the network has enough resource to set up the
   requested LSP.

o Start the data path measurement and/or monitoring procedures on
   the ingress node and egress node. If error free signal is
   received by the egress node before PATH message is sent, report an
   error and terminate the mmeasurement.

o At the ingress node, form the PATH message according to the LSP
   requirements and send the message towards the egress node.

o Upon receiving the last bit of the corresponding RESV message,
   take the time stamp (T1) on the ingress node as soon as possible.

o When an error free signal is observed on the egress node, take the
   time stamp (T2) as soon as possible. An estimate of RRFD (T2 -
   T1) can be computed.

o If the corresponding RESV message arrives, but no error free
   signal is received within a reasonable period of time by the
   ingress node, RRFD is deemed to be undefined.

o If the LSP setup fails, RRFD is not counted.

6. A singleton Definition for RSRD

   This part defines a metric for reverse data path delay when an LSP is
   setup.

   As described in [I-D.shiomoto-ccamp-switch-programming], the
   completion of the RSVP-TE signaling process does not necessarily mean
   that the cross connections along the LSP being setup are in place and
   ready to carry traffic. This metric defines the time difference
   between the completion of the signaling process and the completion of
   the cross connection programming along the reverse data path. This
   metric MAY be used together with RRFD to characterize the data path
   delay of a bidirectional LSP.

6.1. Motivation

   RSRD is useful for several reasons:

   o For the reasons described in
      [I-D.shiomoto-ccamp-switch-programming], the data path may not be
      available instantly after the completion of the RSVP-TE signaling
      process. The delay itself is part of the implementation
      performance.

   o The completion of the signaling process may be used by application
      designers as indication of data path availability. The existence
      of this delay and the possible failure of cross connection
      programming, if not properly treated, will result in data loss or
      application failure. The typical value of this delay can thus
      help designers to improve the application model.

6.2. Metric Name

   RSRD

6.3. Metric Parameters

   o ID0, the ingress LSR ID

   o ID1, the egress LSR ID

   o T, a time when the setup is attempted

6.4. Metric Units

   Either a real number of milli-seconds or undefined.

6.5. Definition

   For a real number dT, RSRD from ingress node ID0 to egress node ID1
   at T is dT means that ingress node ID0 send a PATH message to egress
   node ID1 and the last bit of the corresponding RESV message is sent
   by egress node ID1 at T, and an error free signal is received by the
   ingress node ID0 using a data plane specific test pattern at T+dT.

6.6. Discussion

   The following issues are likely to come up in practice:

   o The accuracy of RSRD depends on the clock resolution of both the
      ingress node and egress node. And clock synchronization between
      the ingress node and egress node is required.

   o The accuracy of RSRD is also dependent on how the error free
      signal is received and may differ significantly when the underline
      data plane technology is different. For instance, for an LSP
      between a pair of Ethernet interfaces, the egress node (sometimes
      the tester) may use a rate based method to verify the availability
      of the data path and use the reception of the first error free
      frame as the error free signal. In this case, the interval
      between two successive frames has a significant impact on
      accuracy. It is RECOMMENDED that in this case the egress node
      uses small intervals, under the condition that the injected
      traffic does not exceed the capacity of the reverse data path.
      The value of the interval MUST be reported.

   o The accuracy of RSRD is also dependent on the time needed to
      propagate the error free signal from the egress node to the
      ingress node. A typical value of propagating the error free
      signal from the egress node to the ingress node under the same
      measurement setup MAY be reported. The methodology to obtain such
      values is outside the scope of this document.

   o If the corresponding RESV message is sent, but no error free
      signal is received by the ingress node within a reasonable period
      of time, RSRD MUST be treated as undefined. The value of the
      threshold MUST be reported.

   o If error free signal is received before PATH message is sent, an
      error MUST be reported and the measurement SHOULD terminate.

   o If the LSP setup fails, RSRD MUST NOT be counted.

6.7. Methodologies

   Generally the methodology would proceed as follows:

   o Make sure that the network has enough resource to set up the
      requested LSPs.

   o Start the data path measurement and/or monitoring procedures on
      the ingress node and egress node. If error free signal is
      received by the ingress node before PATH message is sent, report
      an error and terminate the mmeasurement.

   o At the ingress node, form the PATH message according to the LSP
      requirements and send the message towards the egress node.

   o Upon sending the last bit of the corresponding RESV message, take
      the time stamp (T1) on the egress node as soon as possible.

   o When an error free signal is observed on the ingress node, take
      the time stamp (T2) as soon as possible. An estimate of RSRD
      (T2-T1) can be computed.

   o If the LSP setup fails, RSRD is not counted.

   o If no error free signal is received within a reasonable period of
      time by the ingress node, RSRD is deemed to be undefined.

7. A singleton Definition for PRFD

This part defines a metric for forward data path delay when an LSP is setup.

In an RSVP-TE implementation, when setting up an LSP, each node may choose to program the cross connection before it sends PATH message further downstream. In this case, the forward data path may become available before the signaling process completes, ie. before the RESV reaches the ingress node. This metric can be used to identify such implementation practice and give useful information to application designers.

7.1. Motivation

PRFD is useful for the following reasons:

o PRFD can be used to identify an RSVP-TE implementation practice, in which cross connections are programmed before PATH message is sent downtream.

o The value of PRFD may also help application designers to fine tune their application model.

7.2. Metric Name

PRFD

7.3. Metric Parameters

o ID0, the ingress LSR ID

o ID1, the egress LSR ID

o T, a time when the setup is attempted

7.4. Metric Units

Either a real number of milli-seconds or undefined.

7.5. Definition

For a real number dT, PRFD from ingress node ID0 to egress node ID1 at T is dT means that ingress node ID0 send a PATH message to egress node ID1 and the last bit of the PATH message is received by egress node ID1 at T, and an error free signal is received by the egress node ID1 using a data plane specific test pattern at T+dT.

7.6. **Discussion**

   The following issues are likely to come up in practice:

   o The accuracy of PRFD depends on the clock resolution of the egress
      node. And clock synchronization between the ingress node and
      egress node is not required.

   o The accuracy of PRFD is also dependent on how the error free
      signal is received and may differ significantly when the underline
      data plane technology is different. For instance, for an LSP
      between a pair of Ethernet interfaces, the egress node (sometimes
      the tester) may use a rate based method to verify the availability
      of the data path and use the reception of the first error free
      frame as the error free signal. In this case, the interval
      between two successive frames has a significant impact on
      accuracy. It is RECOMMENDED that in this case the ingress node
      uses small intervals, under the condition that the injected
      traffic does not exceed the capacity of the forward data path.
      The value of the interval MUST be reported.

   o The accuracy of PRFD is also dependent on the time needed to
      propagate the error free signal from the ingress node to the
      egress node. A typical value of propagating the error free signal
      from the ingress node to the egress node under the same
      measurement setup MAY be reported. The methodology to obtain such
      values is outside the scope of this document.

   o If error free signal is received before PATH message is sent, an
      error MUST be reported and the measurement SHOULD terminate.

   o If the LSP setup fails, PRFD MUST NOT be counted.

   o This metric SHOULD be used together with RRFD. It is RECOMMENDED
      that PRFD measurement is carried out after a negetive RRFD value
      has already been observed.

7.7. **Methodologies**

   Generally the methodology would proceed as follows:

   o Make sure that the network has enough resource to set up the
      requested LSPs.

   o Start the data path measurement and/or monitoring procedures on
      the ingress node and egress node. If error free signal is
      received by the egress node before PATH message is sent, report an
      error and terminate the mmeasurement.

o At the ingress node, form the PATH message according to the LSP
   requirements and send the message towards the egress node.

o Upon receiving the last bit of the PATH message, take the time
   stamp (T1) on the egress node as soon as possible.

o When an error free signal is observed on the egress node, take the
   time stamp (T2) as soon as possible. An estimate of PRFD (T2-T1)
   can be computed.

o If the LSP setup fails, PRFD is not counted.

o If no error free signal is received within a reasonable period of
   time by the egress node, PRFD is deemed to be undefined.

8. A Definition for Samples of Data Path Delay

   In Section Section 5, Section 6 and Section 7, we define the
   singleton metrics of data path delay. Now we define how to get one
   particular sample of such delay. Sampling is to select a particular
   potion of singleton values of the given parameters. Like in
   [RFC2330], we use Poisson sampling as an example.

8.1. Metric Name

   Type <X> Data path delay sample, where X is either RRFD, RSRD or
   PRFD.

8.2. Metric Parameters

   o ID0, the ingress LSR ID

   o ID1, the egress LSR ID

   o T0, a time

   o Tf, a time

   o Lambda, a rate in the reciprocal seconds

   o Th, LSP holding time

   o Td, the maximum waiting time for successful LSP setup

   o Ts, the maximum waiting time for error free signal

8.3. Metric Units

   A sequence of pairs; the elements of each pair are:

   o T, a time when setup is attempted

   o dT, either a real number of milli-seconds or undefined

8.4. Definition

   Given T0, Tf, and lambda, compute a pseudo-random Poisson process
   beginning at or before T0, with average arrival rate lambda, and
   ending at or after Tf. Those time values greater than or equal to T0
   and less than or equal to Tf are then selected. At each of the times
   in this process, we obtain the value of data path delay sample of
   type <X> at this time. The value of the sample is the sequence made
   up of the resulting <time, type <X> data path delay> pairs. If there

are no such pairs, the sequence is of length zero and the sample is
said to be empty.

8.5. Discussion

The following issues are likely to come up in practice:

o The parameters lambda, Th and Td should be carefully chosen, as
   explained in the discussions for LSP setup delay.

o The parameter Ts should be carefully chosen and MUST be reported
   along with the LSP forward/reverse data path delay sample.

o Note that for online or passive measurements, the holding time of
   an LSP is determined by actual traffic, hence in this case Th is
   not an input parameter.

8.6. Methodologies

Generally the methodology would proceed as follows:

o The selection of specific times, using the specified Poisson
   arrival process, and

o Set up the LSP and obtain the value of type <X> data path delay

o Release the LSP after Th, and wait for the next Poisson arrival
   process

8.7. Typical testing cases

8.7.1. With No LSP in the Network

8.7.1.1. Motivation

Data path delay with no LSP in the network is important because this
reflects the inherent delay of a device implementation. The minimum
value provides an indication of the delay that will likely be
experienced when an LSP data path is configured under light traffic
load.

8.7.1.2. Methodologies

Make sure that there is no LSP in the network, and proceed with the
methodologies described in Section 8.6.

8.7.2. **With a Number of LSPs in the Network**

8.7.2.1. **Motivation**

   Data path delay with a number of LSPs in the network is important
   because it reflects the performance of an operational network with
   considerable load. This delay may vary significantly as the number
   of existing LSPs varies. It can be used as a scalability metric of a
   device implementation.

8.7.2.2. **Methodologies**

   Setup the required number of LSPs, and wait until the network reaches
   a stable state, and then proceed with the methodologies described in
   Section 8.6.

9. **Some Statistics Definitions for Metrics to Report**

   Given the samples of the performance metric, we now offer several
   statistics of these samples to report. From these statistics, we can
   draw some useful conclusions of a GMPLS network. The value of these
   metrics is either a real number, or an undefined number of
   milliseconds. In the following discussion, we only consider the
   finite values.

9.1. **The Minimum of Metric**

   The minimum of metric is the minimum of all the dT values in the
   sample. In computing this, undefined values SHOULD be treated as
   infinitely large. Note that this means that the minimum could thus
   be undefined if all the dT values are undefined. In addition, the
   metric minimum SHOULD be set to undefined if the sample is empty.

9.2. **The Median of Metric**

   Metric median is the median of the dT values in the given sample. In
   computing the median, the undefined values MUST NOT be counted in.

9.3. **The percentile of Metric**

   Given a metric and a percent X between 0% and 100%, the Xth
   percentile of all the dT values in the sample. In addition, the
   percentile is undefined if the sample is empty.

   Example: suppose we take a sample and the results are: Stream1 =
   <<T1, 100 msec>, <T2, 110 msec>, <T3, undefined>, <T4, 90 msec>,
   <T5,500 msec>>. Then the 50th percentile would be 110 msec, since 90
   msec and 100 msec are smaller, and 110 and 500 msec are larger
   (undefined values are not counted in).

9.4. **The Failure Probability**

   In the process of LSP setup/release, it may fail for some reason.
   The failure probability is the ratio of the unsuccessful times to the
   total times.

10. Security Considerations

   In the control plane, since the measurement endpoints must be
   conformant to signaling specifications and behave as normal signaling
   endpoints, it will not incur other security issues than normal LSP
   provisioning. However, the measurement parameters must be carefully
   selected so that the measurements inject trivial amounts of
   additional traffic into the networks they measure. If they inject
   "too much" traffic, they can skew the results of the measurement, and
   in extreme cases cause congestion and denial of service.

   In the data plane, the measurement endpoint MUST use a signal that is
   consistent with what is specified in the control plane. For example,
   in a packet switched case, the traffic injected into the data plane
   MUST NOT exceed the specified rate in the corresponding LSP setup
   request. In a wavelength switched case, the measurement endpoint
   MUST use the specified or negotiated lambda with appropriate power.

   The security considerations pertaining to the original RSVP protocol
   [RFC2205] and its TE extensions [RFC3209] also remain relevant.

11. IANA Considerations

This document makes no requests for IANA action.

12. Acknowledgements

13. References

13.1. Normative References

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
              Requirement Levels", BCP 14, RFC 2119, March 1997.

   [RFC2205] Braden, B., Zhang, L., Berson, S., Herzog, S., and S.
              Jamin, "Resource ReSerVation Protocol (RSVP) -- Version 1
              Functional Specification", RFC 2205, September 1997.

   [RFC2679] Almes, G., Kalidindi, S., and M. Zekauskas, "A One-way
              Delay Metric for IPPM", RFC 2679, September 1999.

   [RFC2681] Almes, G., Kalidindi, S., and M. Zekauskas, "A Round-trip
              Delay Metric for IPPM", RFC 2681, September 1999.

   [RFC3209] Awduche, D., Berger, L., Gan, D., Li, T., Srinivasan, V.,
              and G. Swallow, "RSVP-TE: Extensions to RSVP for LSP
              Tunnels", RFC 3209, December 2001.

13.2. Informative References

   [I-D.ietf-ccamp-lsp-dppm]
              Sun, W., Zhang, G., Gao, J., Xie, G., Papneja, R., Gu, B.,
              Wei, X., Otani, T., and R. Jing, "Label Switched Path
              (LSP) Dynamic Provisioning Performance Metrics in
              Generalized MPLS Networks", draft-ietf-ccamp-lsp-dppm-10
              (work in progress), October 2009.

   [I-D.shiomoto-ccamp-switch-programming]
              Shiomoto, K. and A. Farrel, "Advice on When It is Safe to
              Start Sending Data on Label Switched Paths Established
              Using RSVP-TE", draft-shiomoto-ccamp-switch-programming-01
              (work in progress), October 2009.

   [RFC2330] Paxson, V., Almes, G., Mahdavi, J., and M. Mathis,
              "Framework for IP Performance Metrics", RFC 2330,
              May 1998.

Authors' Addresses

   Weiqiang Sun, Editor
   Shanghai Jiao Tong University
   800 Dongchuan Road
   Shanghai 200240
   China

   Phone: +86 21 3420 5359
   Email: sunwq@mit.edu

   Guoying Zhang, Editor
   China Academy of Telecommunication Research, MIIT, China.
   No.11 YueTan South Street
   Beijing 100045
   China

   Phone: +86 1068094272
   Email: zhangguoying@mail.ritt.com.cn

   Jianhua Gao
   Huawei Technologies Co., LTD.
   China

   Phone: +86 755 28973237
   Email: gjhhit@huawei.com

   Guowu Xie
   University of California, Riverside
   900 University Ave.
   Riverside, CA 92521
   USA

   Phone: +1 951 237 8825
   Email: xieg@cs.ucr.edu

   Rajiv Papneja
   Isocore
   12359 Sunrise Valley Drive, STE 100
   Reston, VA 20190
   USA

   Phone: +1 703 860 9273
   Email: rpapneja@isocore.com

Contributors

   Bin Gu
   IXIA
   Oriental Kenzo Plaza 8M, 48 Dongzhimen Wai Street, Dongcheng District
   Beijing 200240
   China

   Phone: +86 13611590766
   Email: BGu@ixiacom.com

   Xueqin Wei
   Fiberhome Telecommunication Technology Co., Ltd.
   Wuhan
   China

   Phone: +86 13871127882
   Email: xqwei@fiberhome.com.cn

   Tomohiro Otani
   KDDI R&D Laboratories, Inc.
   2-1-15 Ohara Kamifukuoka Saitama
   356-8502
   Japan

   Phone: +81-49-278-7357
   Email: otani@kddilabs.jp

   Ruiquan Jing
   China Telecom Beijing Research Institute
   118 Xizhimenwai Avenue
   Beijing 100035
   China

   Phone: +86-10-58552000
   Email: jingrq@ctbri.com.cn