ITU-T Kaleidoscope Conference
Innovations in NGN

TWO BUFFER MODEL-BASED QoS ESTIMATION METHOD FOR 3G WIRELESS IP NETWORKS IN BULLET TRAINS

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Outline

- Summary
- The proposed measurement
- The QoS estimation method
- The experiment and result
- Conclusions and Future Works

Summary

- We are aiming at improving transport layer protocols over 3G wireless IP networks in high-speed mobile environment.
- It is necessary to make a model of high-speed mobile communication environment on the simulator.
  - To do this, measurement of the communication quality and the raw packet transmission characteristics of the 3G is necessary
- We will introduce a two buffer model-based QoS estimation method used to measure the raw packet transmission characteristics of CDMA2000 1xEV-DO in bullet trains.

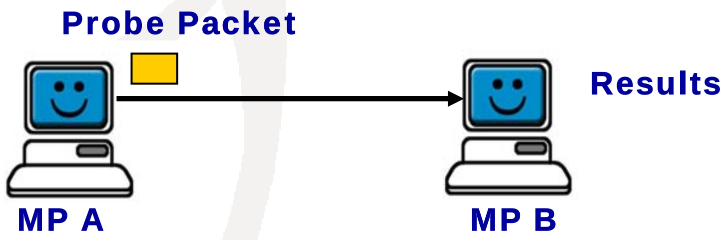
Definition of communication quality and measurement (ITU-T Recommendations)

- IP packet transfer delay (IPTD)
- IP packet delay variation (IPDV)
- IP packet loss ratio (IPLR)
- IP packet error ratio (IPER)

		QoS classes					
Network performance parameter	Nature of network performance objective	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5 (unspecified)
IPTD	Upper bound on the mean IPTD	100 ms	400 ms	100 ms	400 ms	1 s	U
IPDV	Upper bound on the $1-10^{-3}$ quantile of IPTD minus the minimum IPTD)	50 ms	50 ms	U	U	U	U
IPLR	Upper bound on the packet loss probability	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	U
IPER	Upper bound	$1*10^{-4}$	$1*10^{-4}$	$1*10^{-4}$	$1*10^{-4}$	$1*10^{-4}$	U

Note: U = unspecified.

- **One-way measurement**
- **The probe packet will be**
  - **UDP–echo based**
  - **Time-stamped at injection and extraction devices**



- **The measurement points (MP) are fixed and the path is invariable**
- **Clock synchronization of two measurement points is necessary**

Issues of communication qualities in bullet trains

1. The mobile station (MS) keep moving the entire time and the communication channel characteristics differ according to the geographical location of the MS.
   - we need to define the invariant communication qualities of this environment and find a method for the measure of communication performance.
2. In order to get the raw packet transmission characteristics of 3G wireless IP networks, we need to avoid the influence of possible packet buffers and transport layer protocols like W-TCP.
   - We can only observe the communication performance over IP layer.
   - We avoid measuring the network performance with tools using TCP.
3. The one-way measurement need to synchronize the clock of the two measurement points.
   - There are many tunnels along the route, so it is very difficult to realize the clock synchronization by using GPS.

Proposed measurement

- Define Route Characteristics in Bullet Trains as a set of the following measurements

$RP_B = \{< Delay_i, Jitter_i, Packet\_Loss_i, Availability_i > | i \in Locations\}$

- Locations are sampled in a specified time-interval between the start station and the terminal station.
- Each measurement varies geographically.
- We want to get statistical values from RP_B

For #1 issue

Proposed measurement

- A proposed measurement from the view of users
  - Traditional two-way measurement (RTT)

    For #3 issue

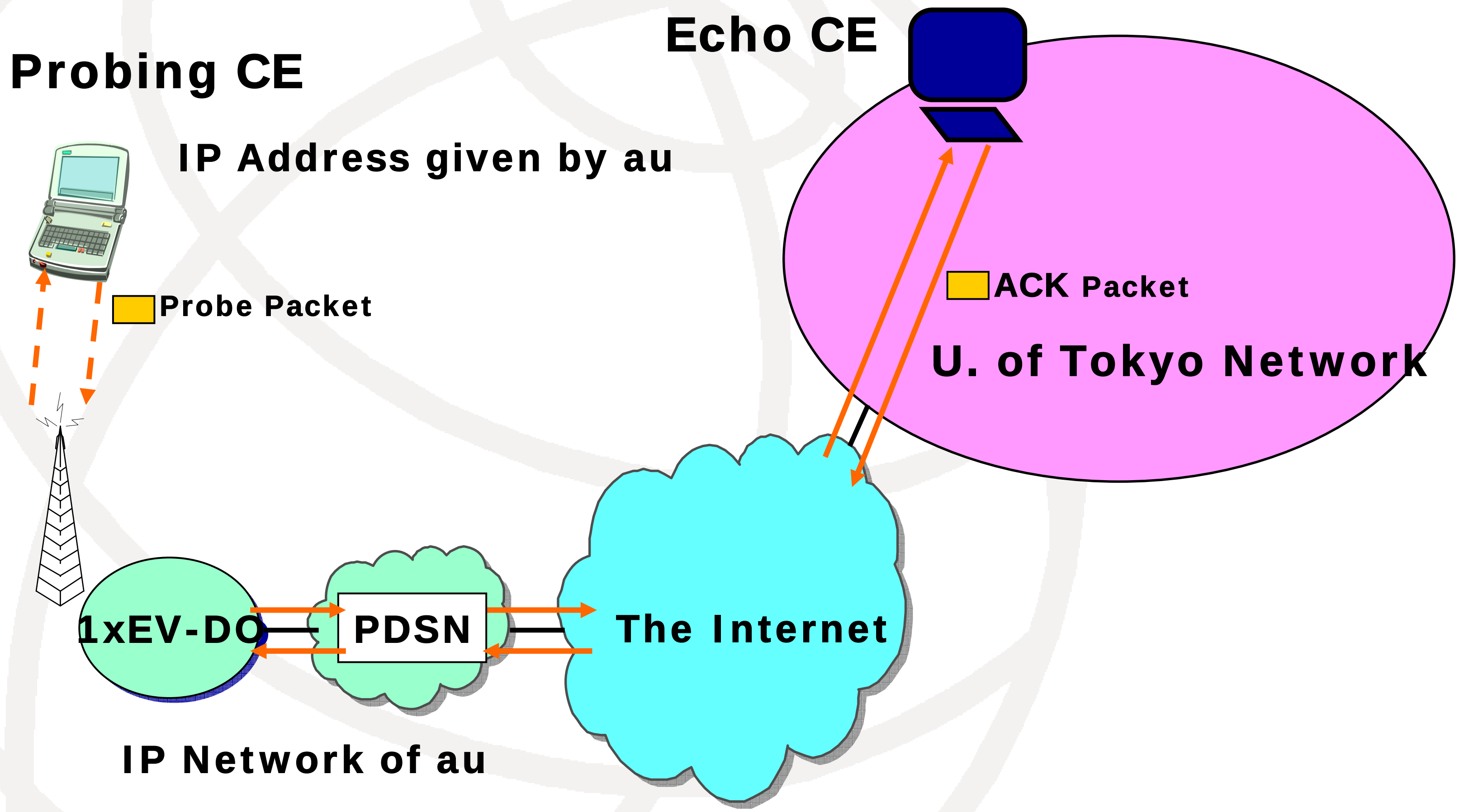
  - ICMP-echo packets in a specified time-interval
    - The size of probe packet is 84 bytes.
    - The measurement interval is set to 1 second
    - Measure from the starting station to the terminal station

    For #2 issue

  - Two buffer model-based QoS estimation method is used to measure the raw packet transmission characteristics

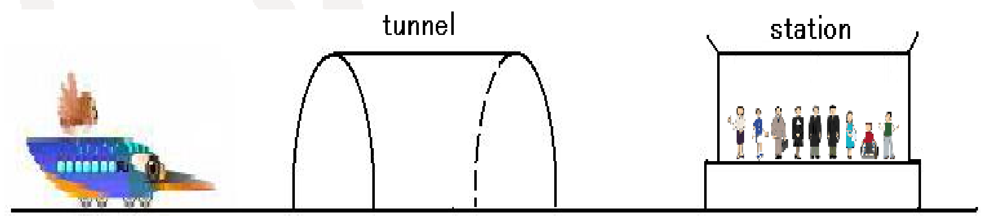
    For #2 issue

How to measure:
Network configurations of our experiment



What to Measure: The data of our experiment

- We measure following data at each location segment *i*
  - RTT ($Delay_i$, $Jitter_i$)
  - Packet Loss Ratio ($Packet\_Loss_i$)
  - Probing CE Status (PCE_Status_i)



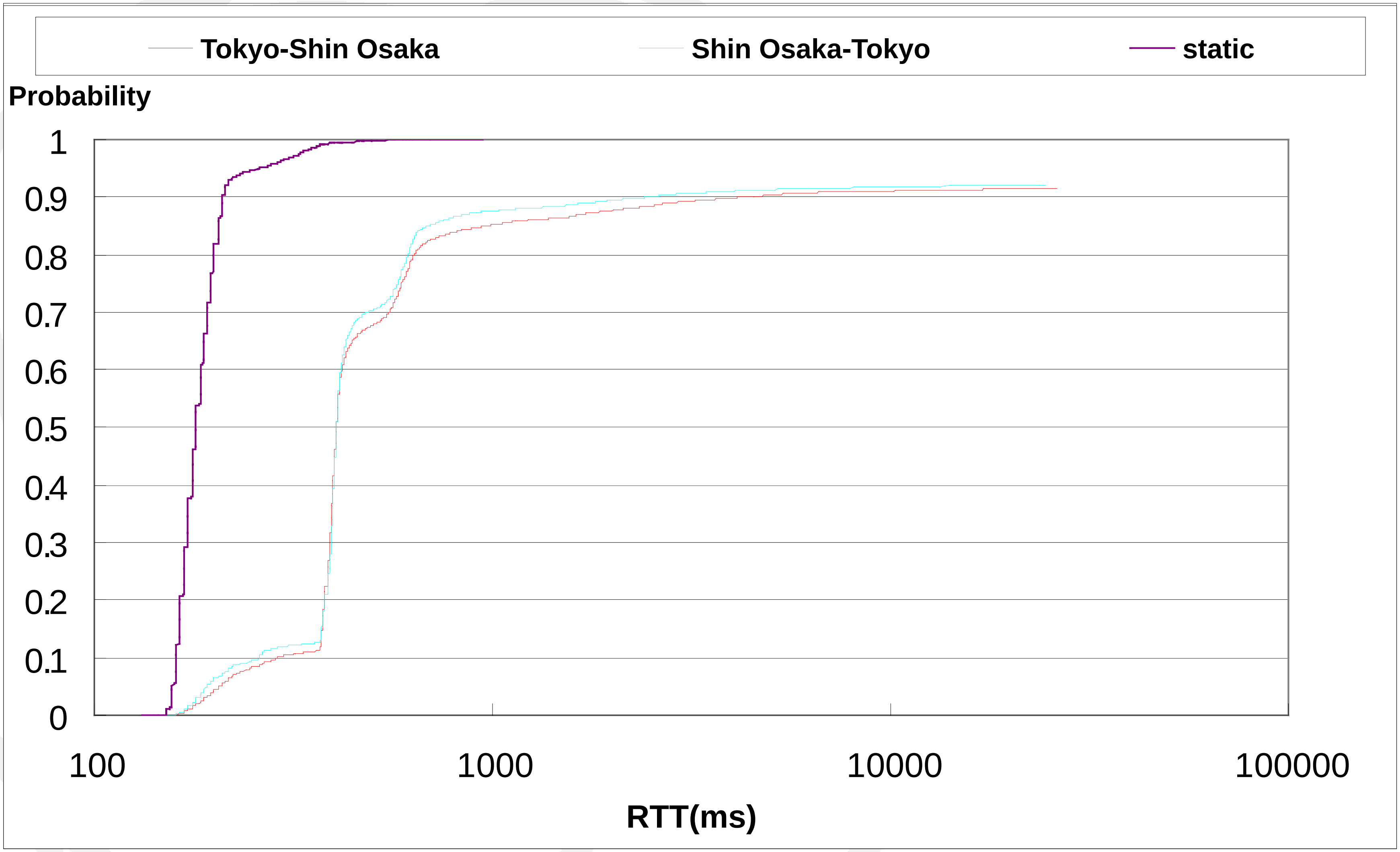
- Experiment Target Line
  - Tokaido Shinkansen (Tokyo－Shin Osaka)「Nozomi」

No throughput measurement at this time

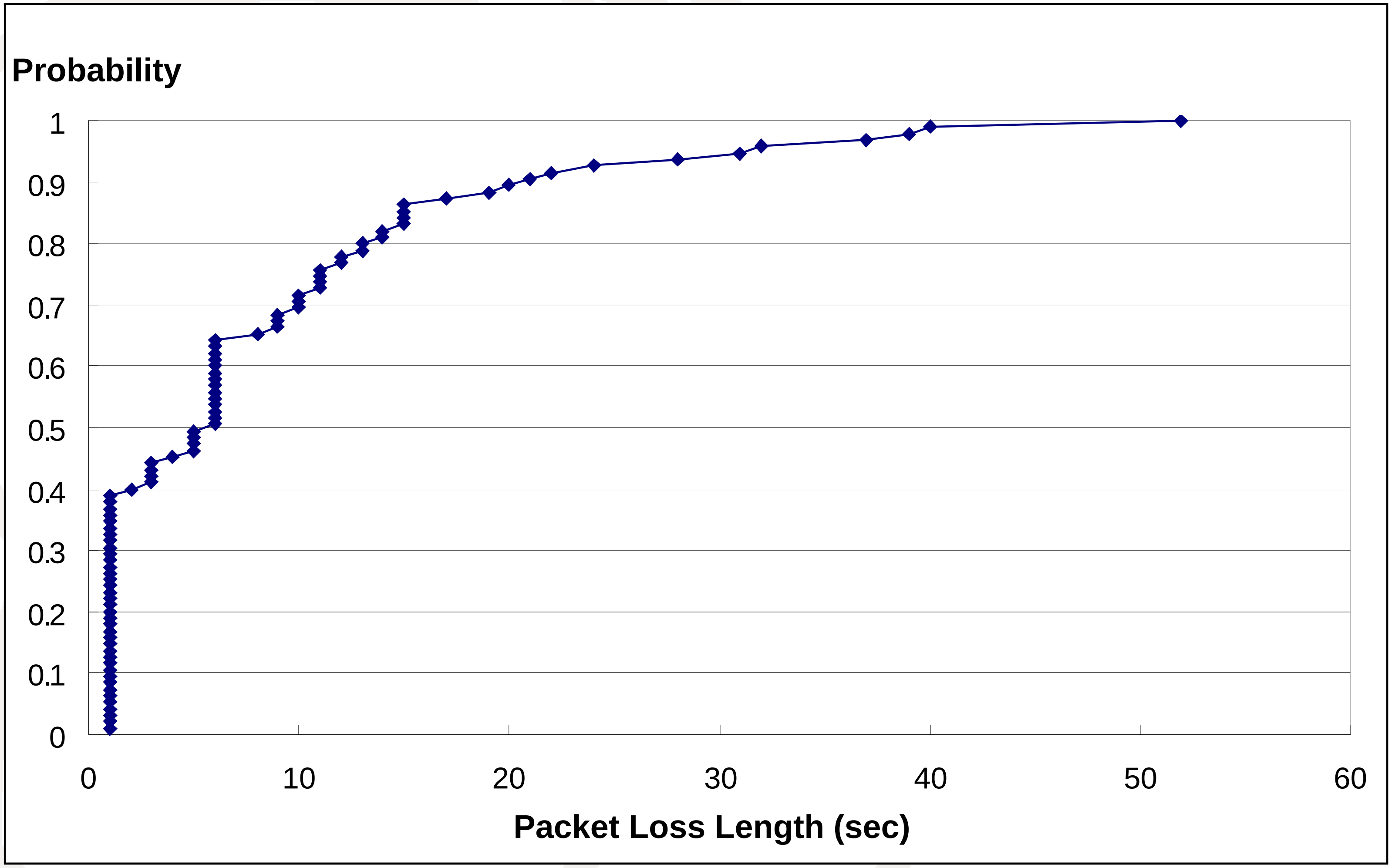
RTT data

RTT (ms)	Tokyo-Shin Osaka	Shin Osaka-Tokyo	Static
Min	140	132	131
Max	26199	24503	948
Average (mean)	661	575	189
Median	400	404	108
Standard deviation	1402	1088	42.6
Packet Loss Ratio	8.5%	7.9%	0%

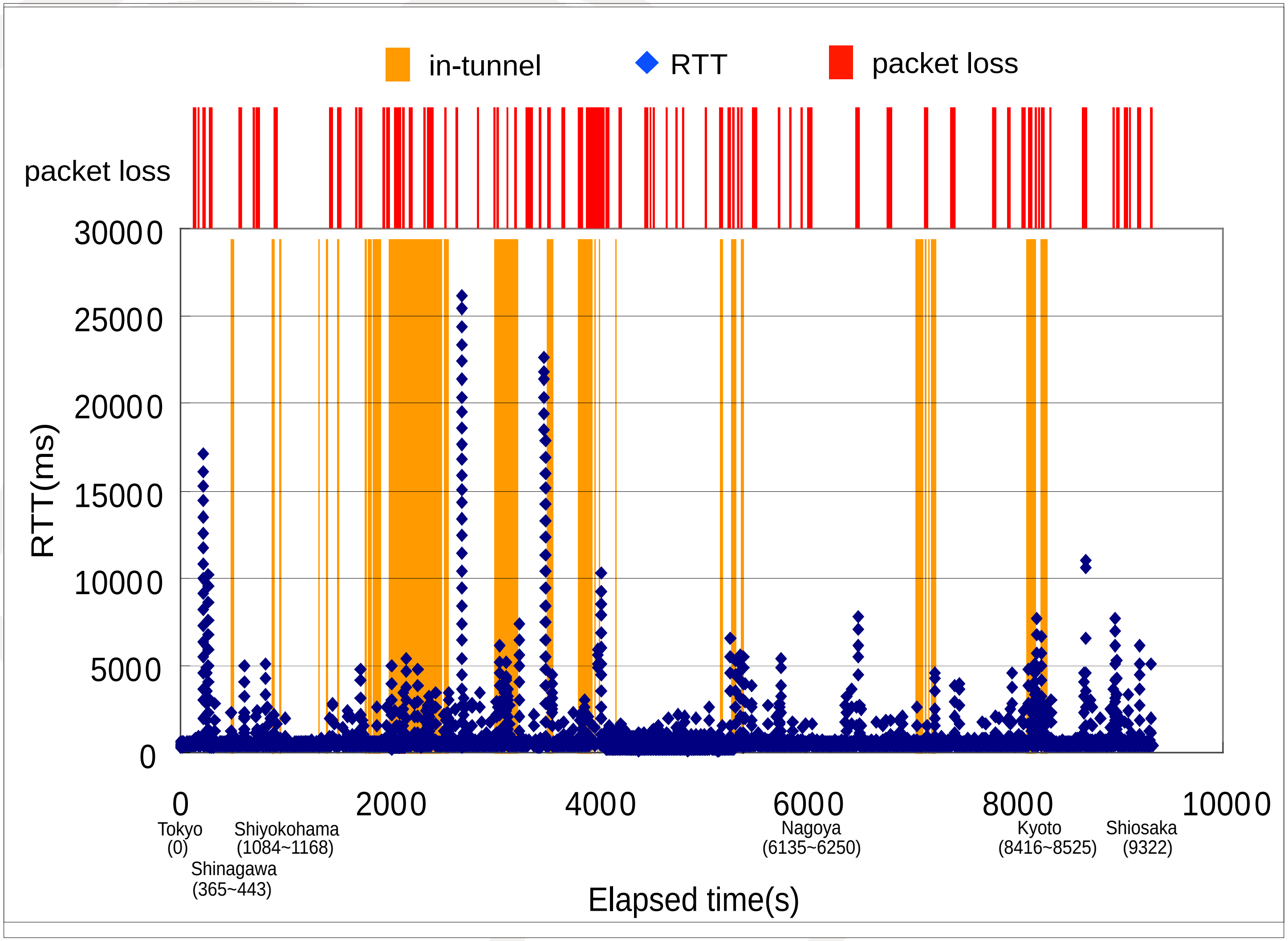
Cumulative distribution of RTT



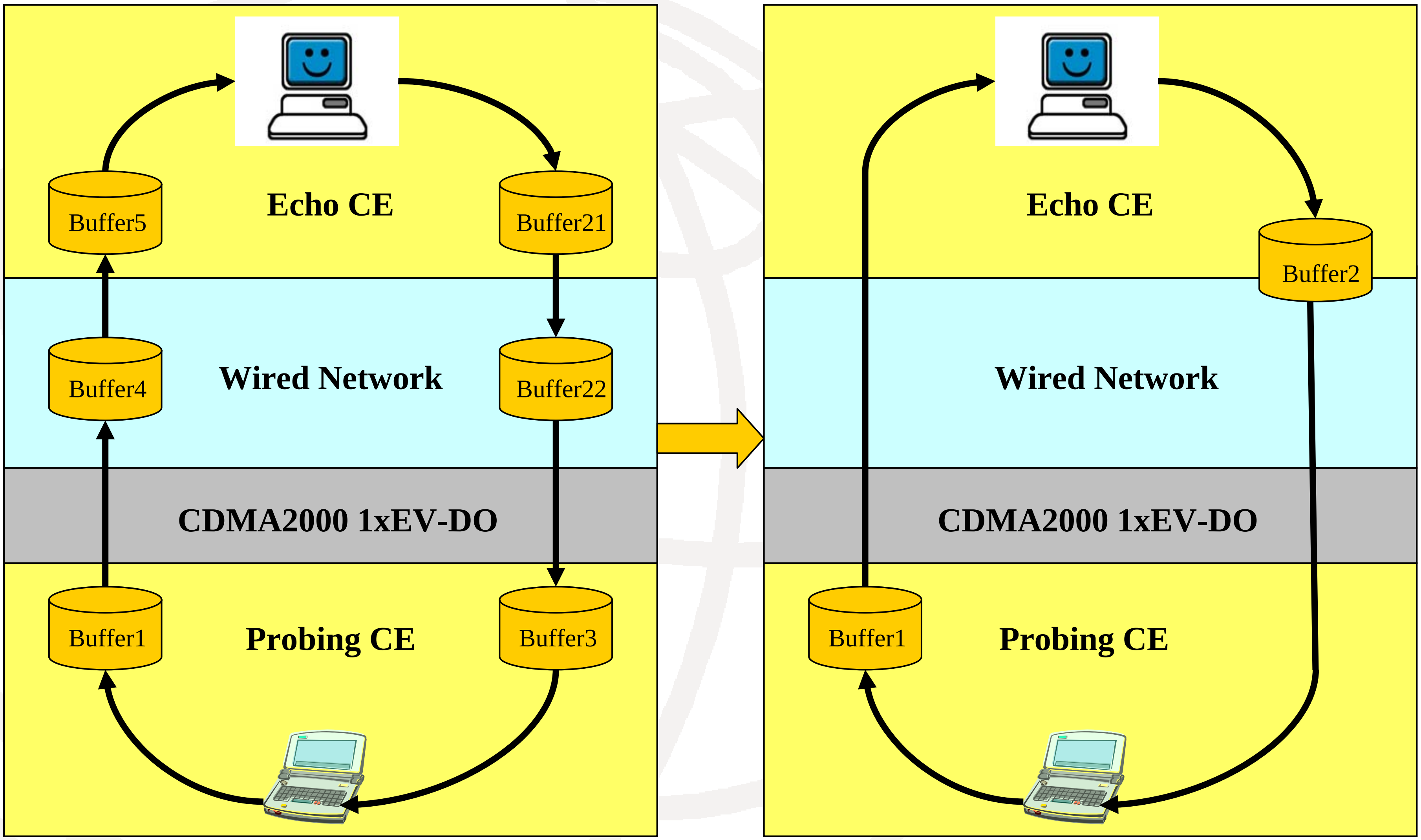
Cumulative distribution of packet loss length for Tokyo-Shin Osaka



Tokyo-Shin Osaka RTT and Packet Loss



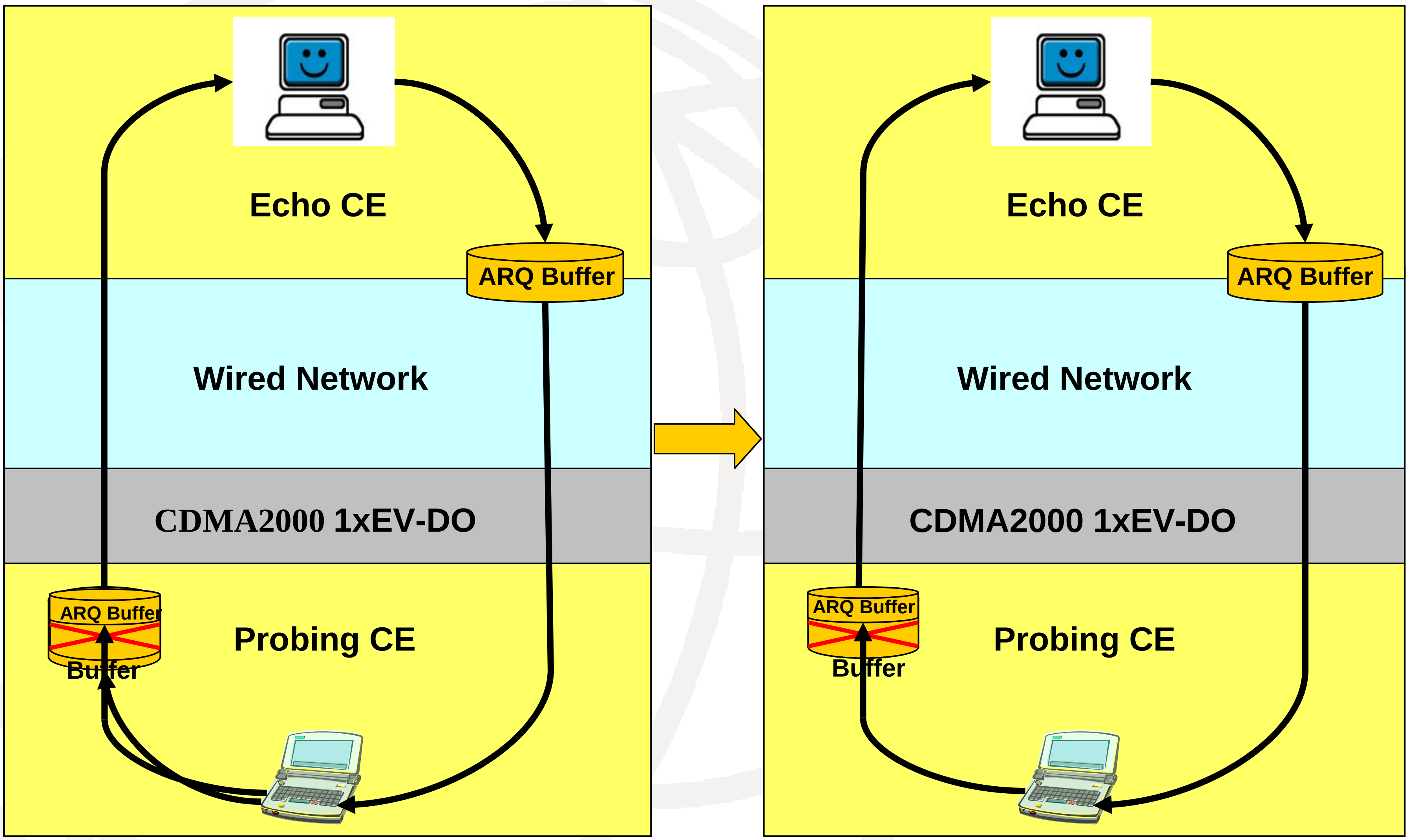
Model of wireless communication environment



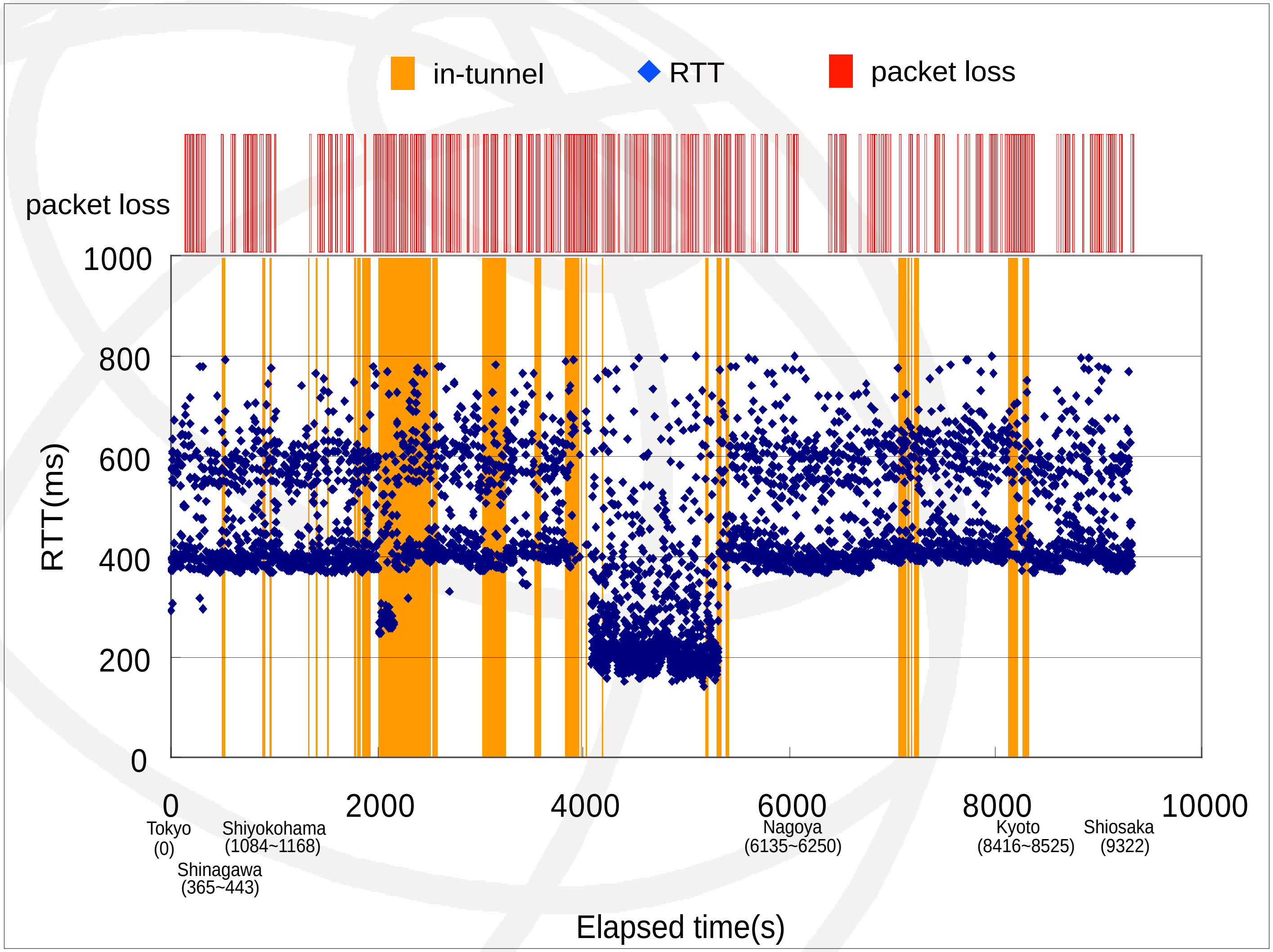
How to eliminate the buffer function from the network

- The original TCP specification had TCP update a smoothed RTT estimator (called R) using the low-pass filter:
  - $R \longleftarrow \alpha R + (1 - \alpha)M, \ \alpha = 0.9.$
- RFC793 recommended the retransmission timeout value (RTO) be set to as follow:
  - $RTO = R\beta, \ \beta = 2.$
- From the point of transport layer protocols, a large delay is logically considered to be a link down
  - We consider that the packet whose RTT is larger than the 2 times of median of RTT is influenced by the buffer1 for the link-down period.

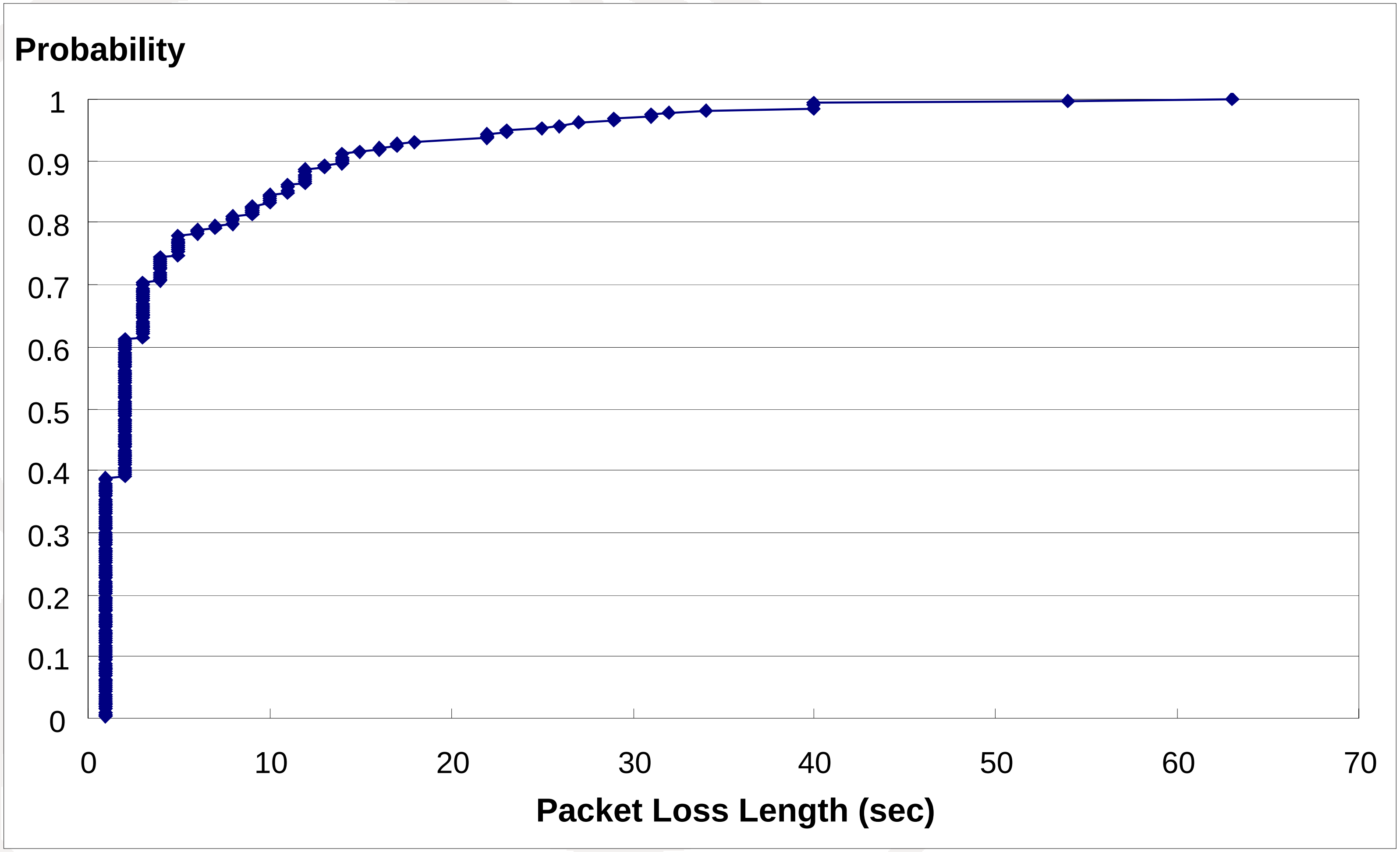
Model of CDMA2000 1xEV-DO communication environment



Tokyo-Shin Osaka RTT and Packet Loss (No link-down backup function)



Cumulative distribution of packet loss length for Tokyo-Shin Osaka (No link-down backup function)



Conclusions and future works

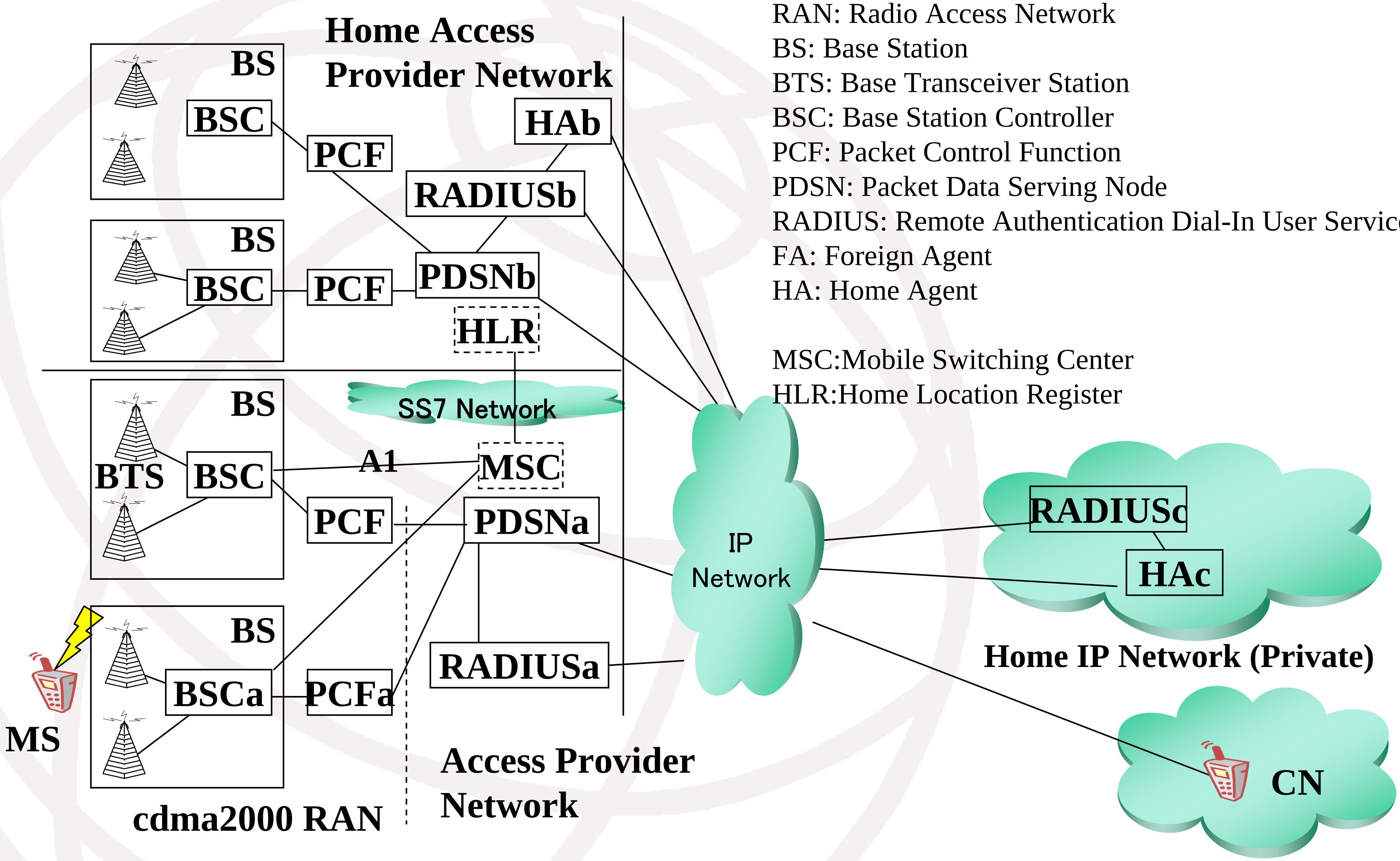
- Conclusions
  - The route characteristics are introduced in QoS metrics for communication qualities in bullet trains.
  - Traditional two-way ICMP-echo measurement in a specified interval can be used to measure them.
  - A two buffer model-based QoS estimation method is **proposed** to eliminate the influence by a large buffer in NIC of PC.
  - The raw packet transmission characteristics of CDMA2000 1xEV-DO using the estimation method are gotten.

- Future works
  - The throughput will be statistically estimated by packet-pair probing. (Preliminary results were got from packets in delay spikes.)
  - Using these parameters, make a model of high speed mobile communication environment on the simulator.

Thank you for your attention!

Modified from 3GPP2, “cdma2000 Wireless IP Network Standard: Introduction,” X.S0011-001-D, http://www.3gpp2. org/Public_html/specs/X.S0011-001-D_v1.0_060301.pdf, Feb.2006.

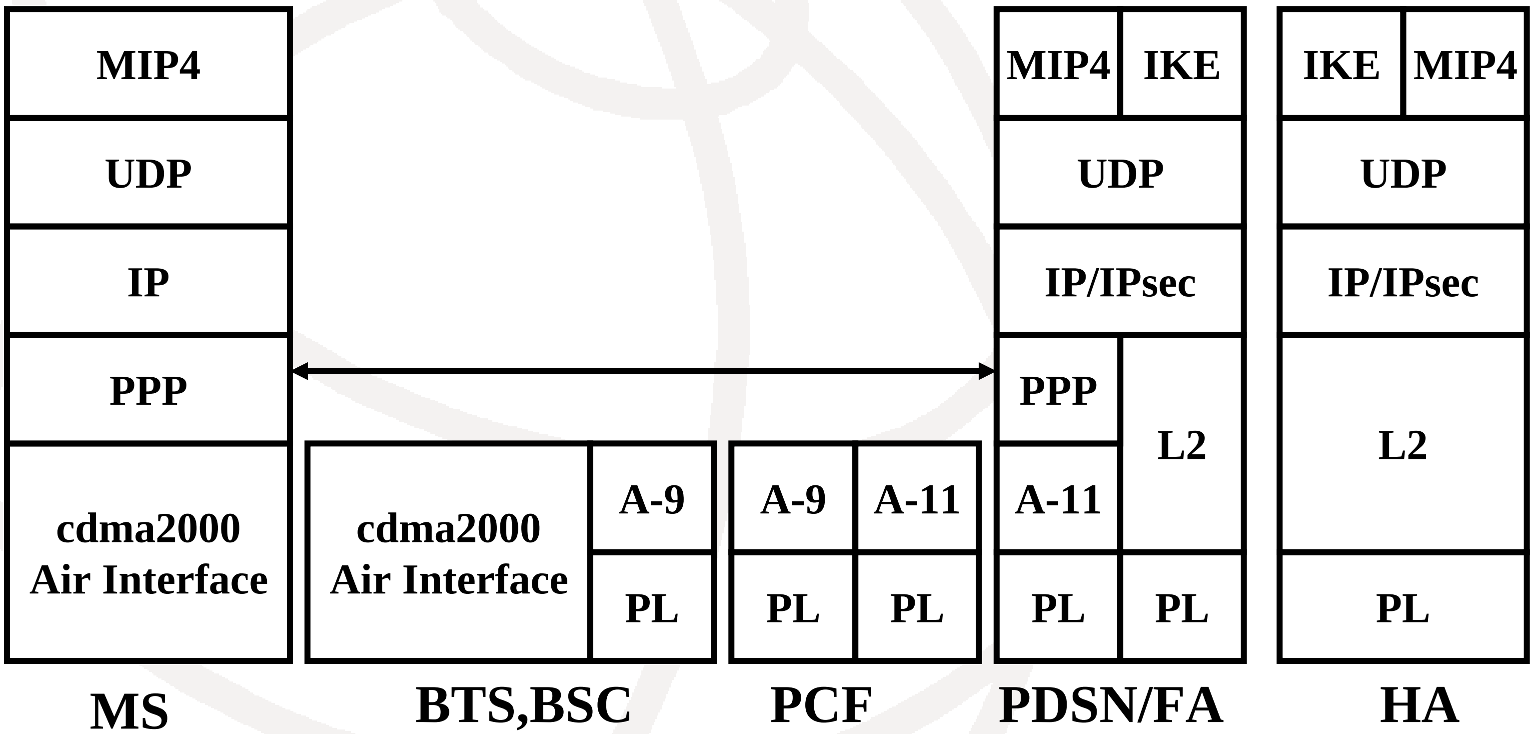
3GPP2 Mobile IP



MS: Mobile Station
RAN: Radio Access Network
BS: Base Station
BTS: Base Transceiver Station
BSC: Base Station Controller
PCF: Packet Control Function
PDSN: Packet Data Serving Node
RADIUS: Remote Authentication Dial-In User Service
FA: Foreign Agent
HA: Home Agent

MSC:Mobile Switching Center
HLR:Home Location Register

(a) CDMA2000 1xEV-DO Protocol Reference Model for MIP4 Control and IKE



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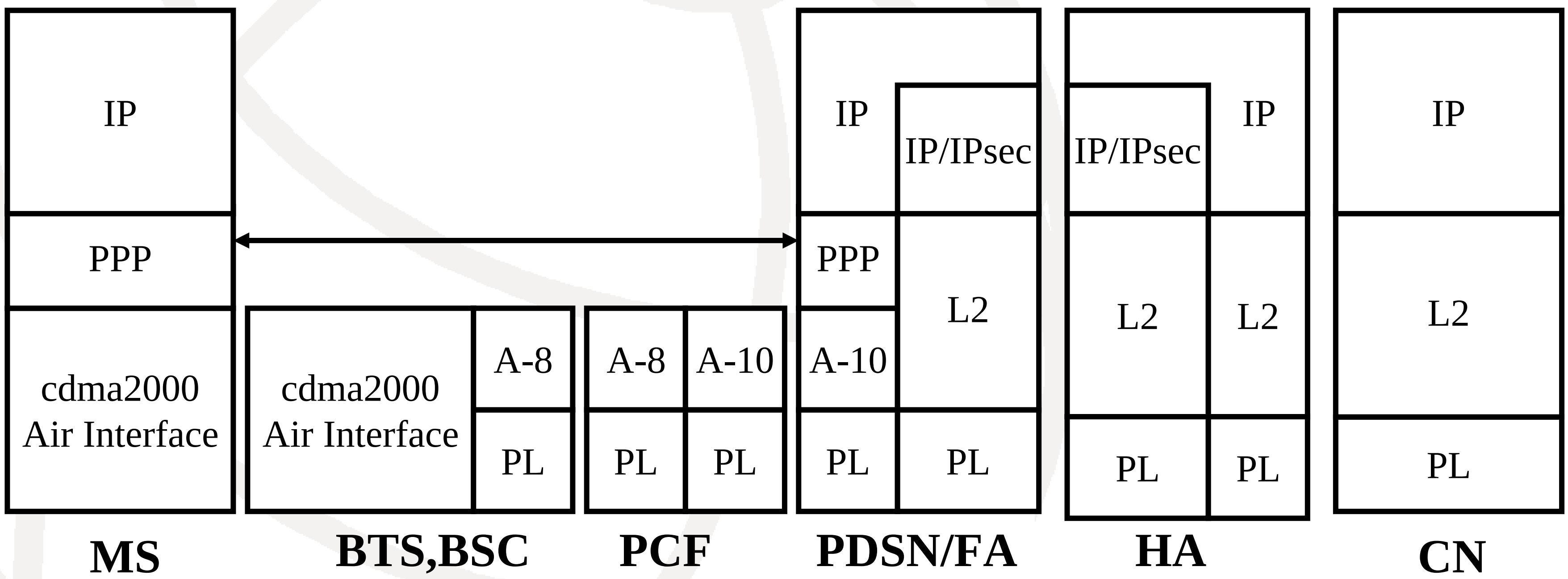
(b) CDMA2000 1xEV-DO Protocol Reference Model for MIP4 User Data



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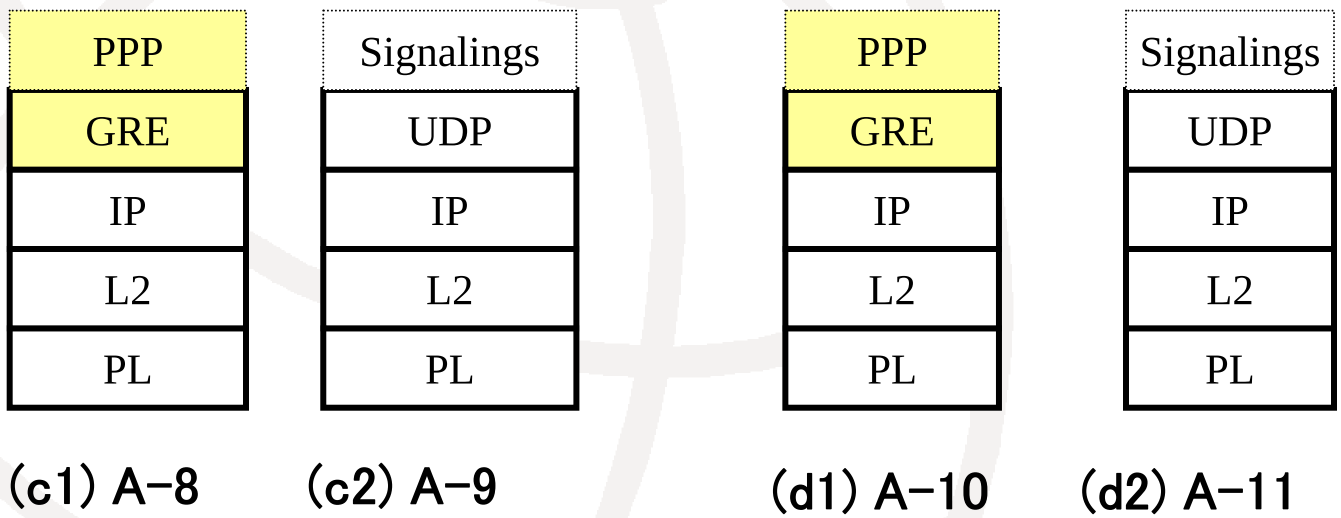

(c) BSC-PCF Interface

(d) PCF-PDSN Interface