On the Sensitivity of Online Game Playing Time to Network QoS

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Talk Outline

- Overview
- Trace collection
- Analysis and modeling of the relationship between session times and QoS
- Implications and applications
- Summary

Motivation

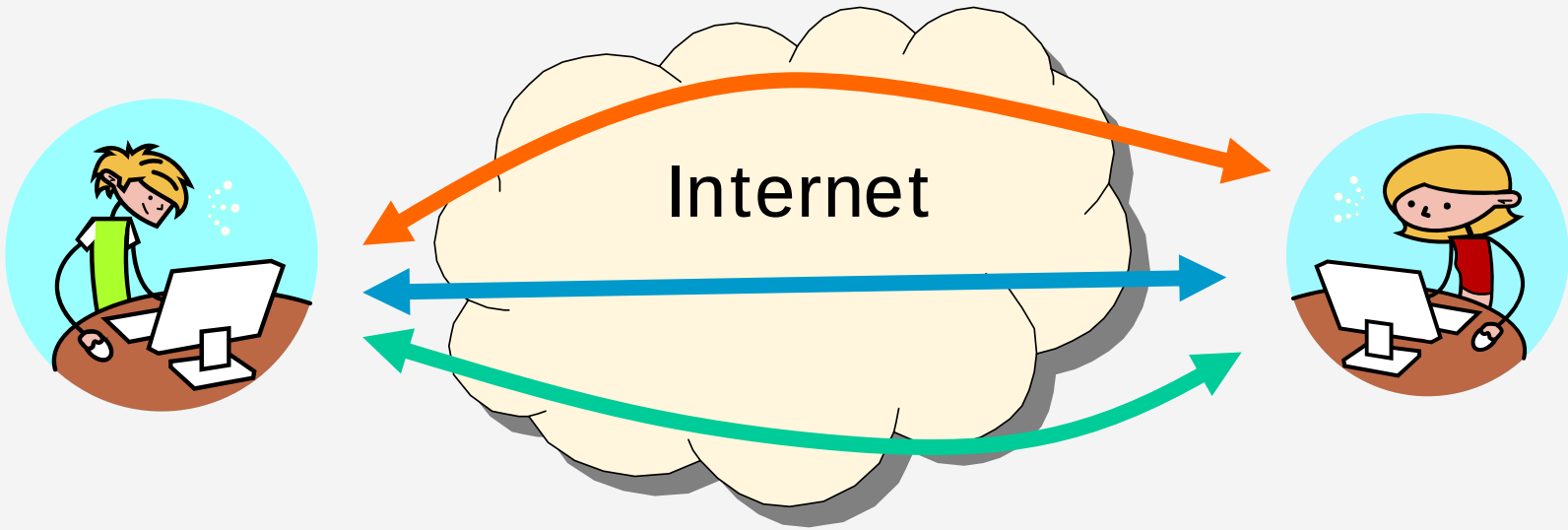
- Real-time interactive online games are generally considered QoS-sensitive
- Gamers always complain about high “ping-times” or network lags

- Online gaming is increasly popular depsite the best-effort Internet

Q1: Are players really sensitive to network quality as they claim?

Q2: If so, how do they react to poor network quality?

Assessment of User Satisfaction

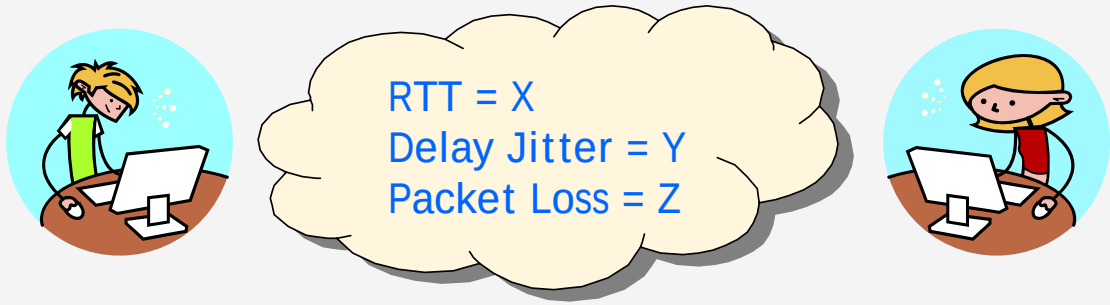


Which path can provide the best user experience?

Path	Latency	Delay Jitter	Loss	Satisfaction
1	Good	Poor	Average	?
2	Average	Good	Poor	?
3	Poor	Average	Good	?

Previous Work

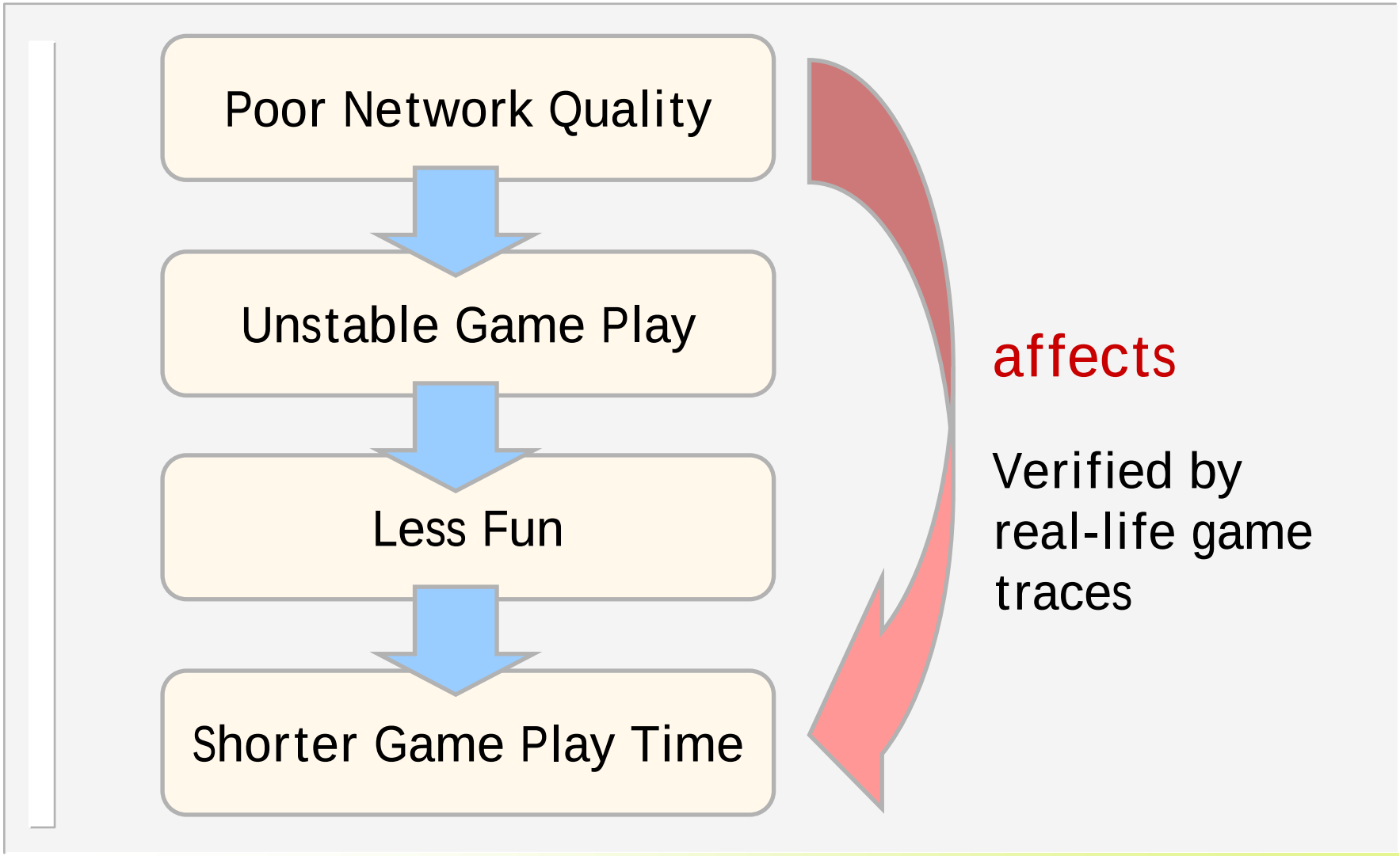
- Evaluating the enjoyment of game playing in a controlled network environment



  - Subjective evaluation is costly and not scalable
  - Objective evaluation is not generalizable
    - Shooting games: number of kills
    - Racing games: time taken to complete each lap
    - Strategy games: capital accumulated

Real-life user behavior is not measurable in a controlled experiment

Our Conjecture



Key Contributions / Findings

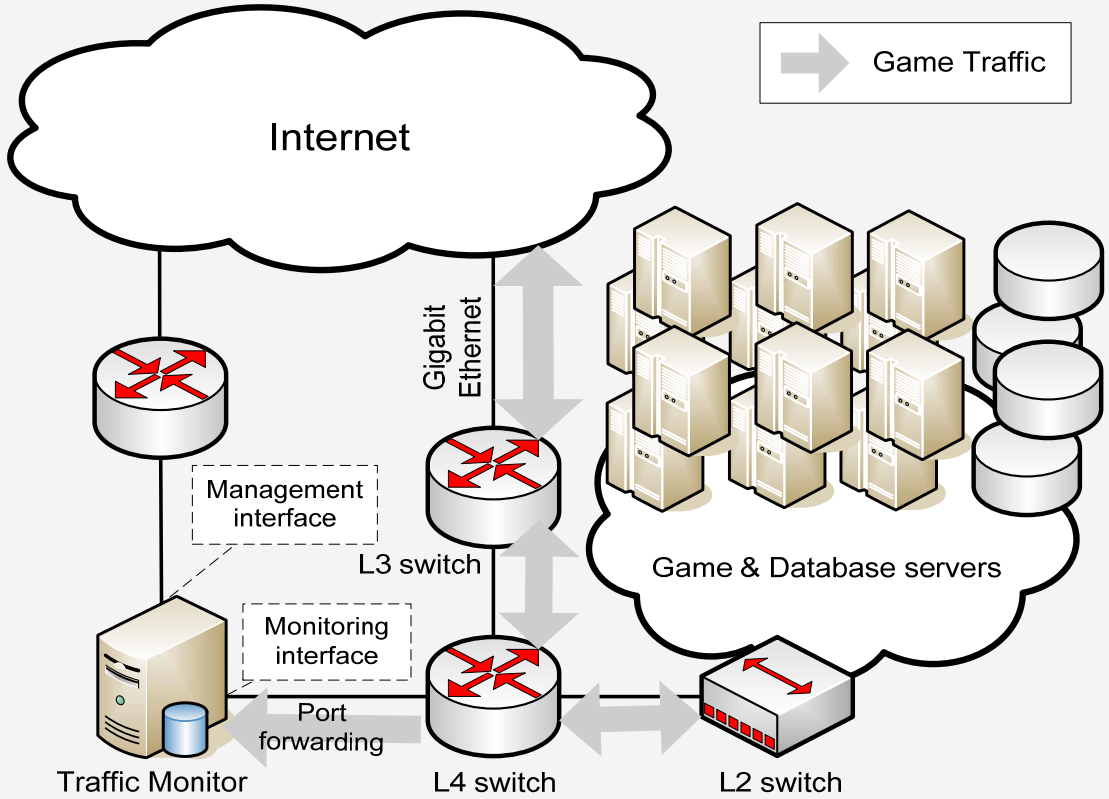
- Session time as a means to measure users' feeling about network quality
- Players are sensitive to network conditions (in terms of game playing time)
- Proposed a time-QoS model to quantify the impact of network quality

$$\log(\text{departure rate}) \propto 1.27 \times \log(rtt) + 0.68 \times \log(jitter) + 0.12 \times \log(closs) + 0.09 \times \log(sloss)$$

ShenZhou Online

- A commercial MMORPG in Taiwan
- Thousands of players online at anytime
- TCP-based client-server architecture

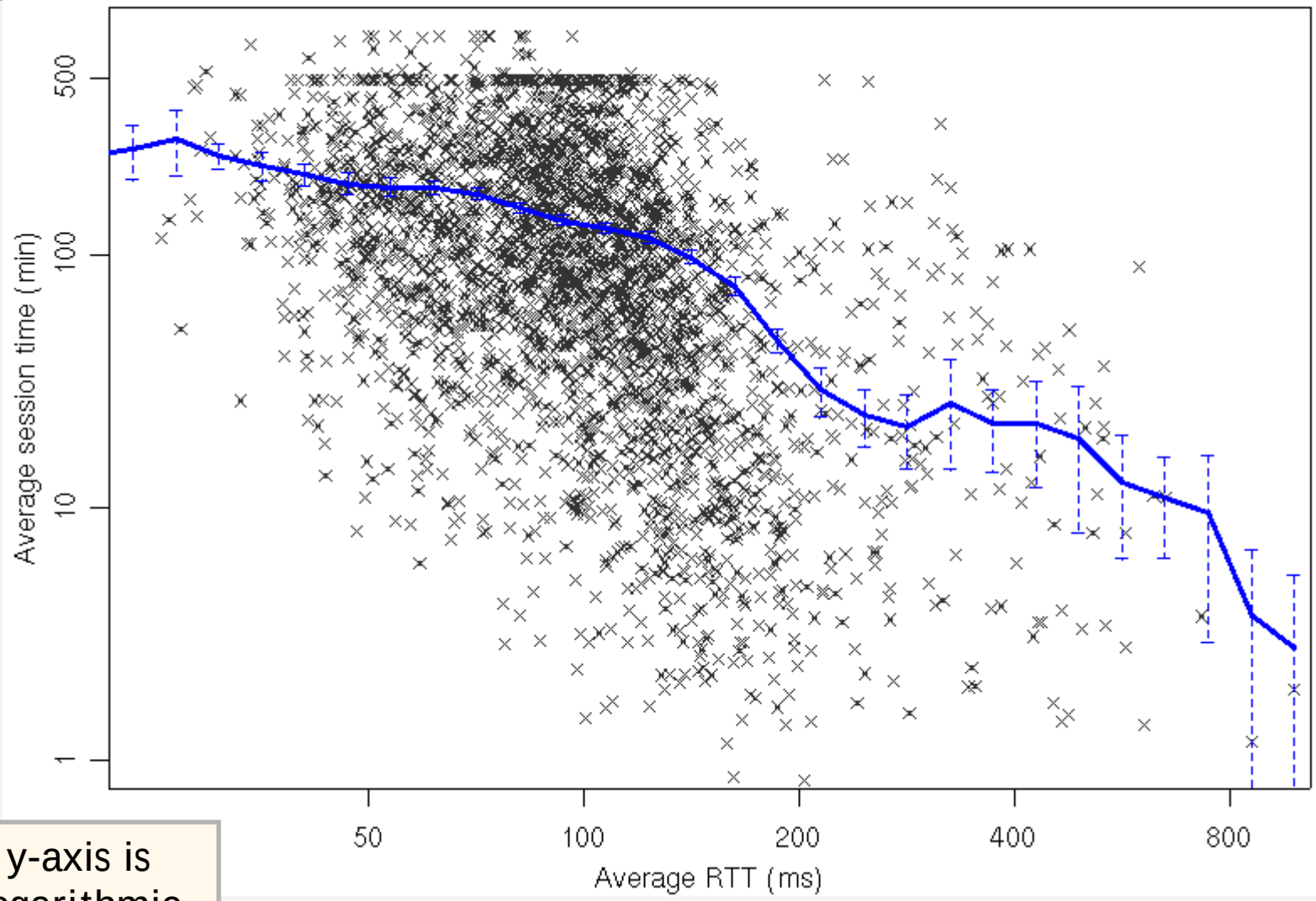
Trace Collection



Session #	Avg. Time	Top 20%	Bottom 20%
15,140	100 min	> 8 hours	< 40 min

(20 hours and 1,356 million packets)

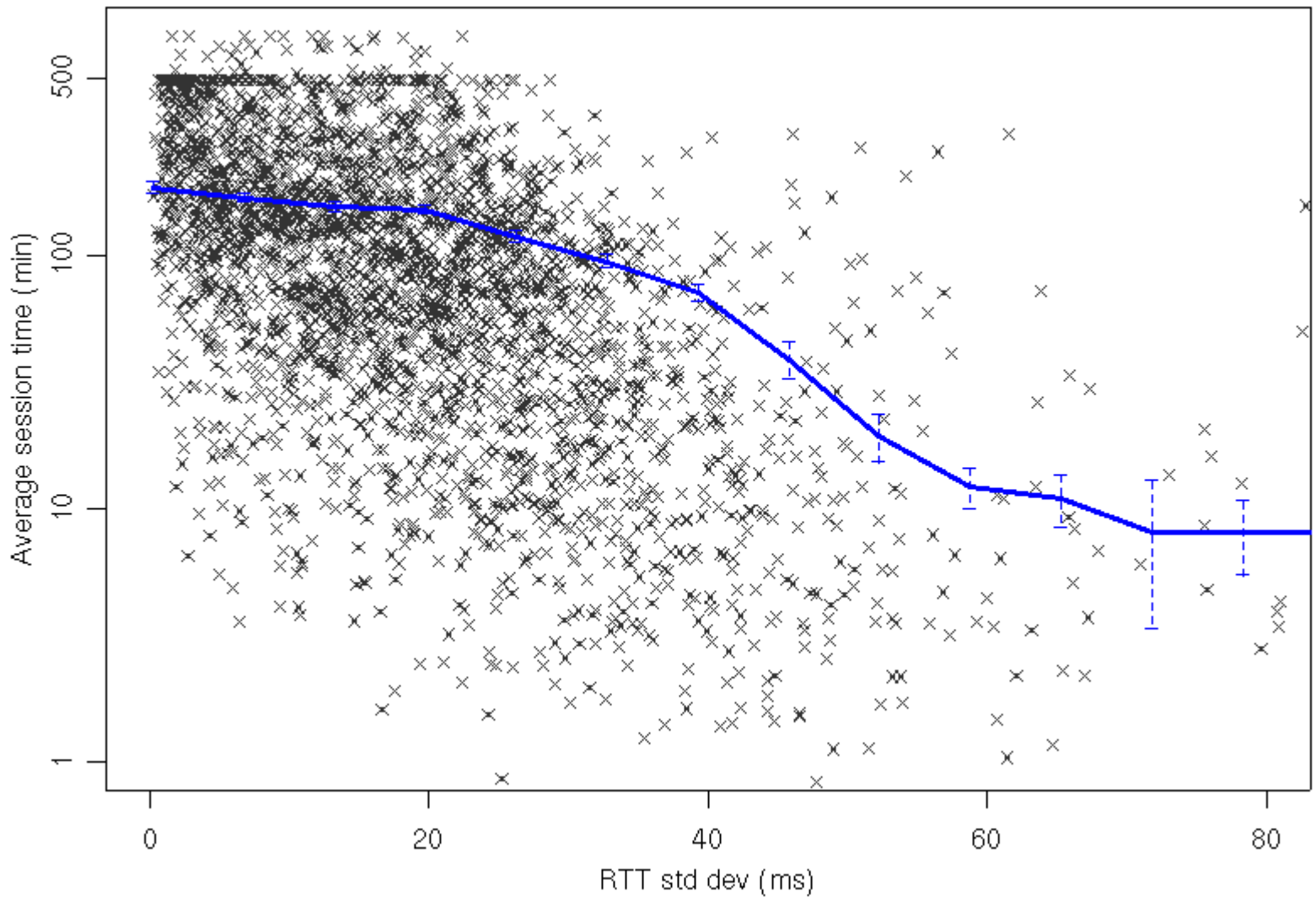
Round-Trip Times vs. Session Time



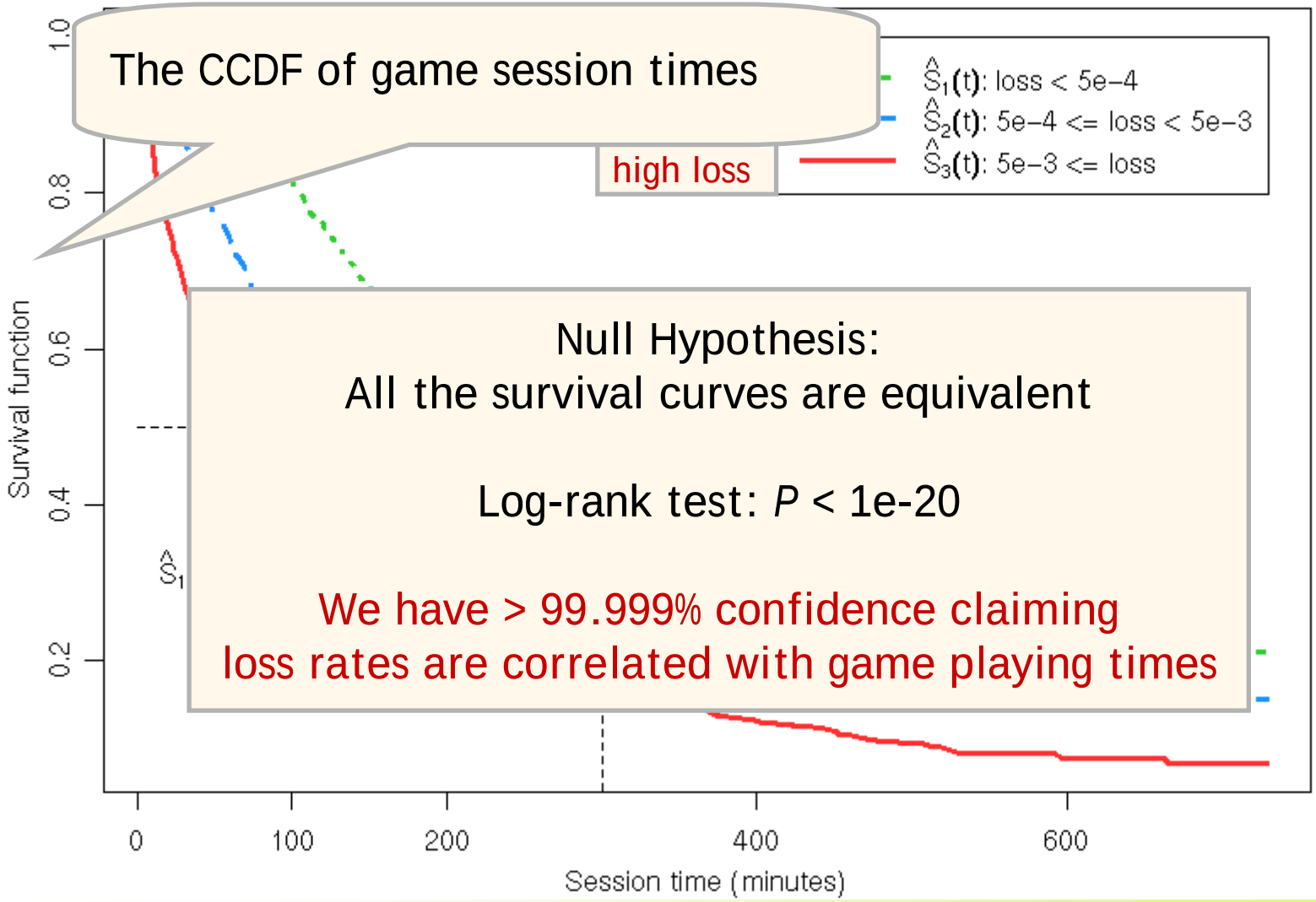
y-axis is logarithmic

Delay Jitter vs. Session Time

(std. dev. of the round-trip times)



Hypothesis Testing -- Effect of Loss Rate



Effect of QoS Factors -- Overview

QoS Factor	Significant?	Correlation
Average RTT	Yes	Negative
Delay Jitter	Yes	Negative
Client Packet Loss	Yes	Negative
Server Packet Loss	Yes	Negative
Queueing Delay	No	N/A

(significant: p-value < 0.01)

Regression Modeling

- Linear
  - Violating the [illegible] (normal errors, equal variance, ...)
- The Cox regression model provides a good fit
  - Log-hazard function is proportional to the weighted sum of factors

$$\log h(t|\mathbf{Z}) \propto \boldsymbol{\beta}^t \mathbf{Z}$$ (our aim is to compute $\boldsymbol{\beta}$)

where each session has factors Z (RTT=x, jitter=y, ...)

Commonly used to model the effect of treatment on the survival time or relapse time of patients

Hazard function (conditional failure rate)
The instantaneous rate of quitting a game for a player (session)

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr[t \leq T < t + \Delta t | T \geq t]}{\Delta t}$$

Model Fitting

- $h(t|\mathbf{Z}_i) \propto \exp(\beta^t \mathbf{Z}_i)$ must be conformed
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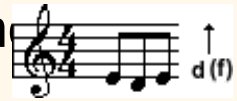
Human beings are known sensitive to the scale of physical magnitude rather than the magnitude itself

- Scale of sound (decibels vs. intensity)

- Musical staff for notes (distance vs. frequen



- Star magnitudes (magnitude vs. brightne

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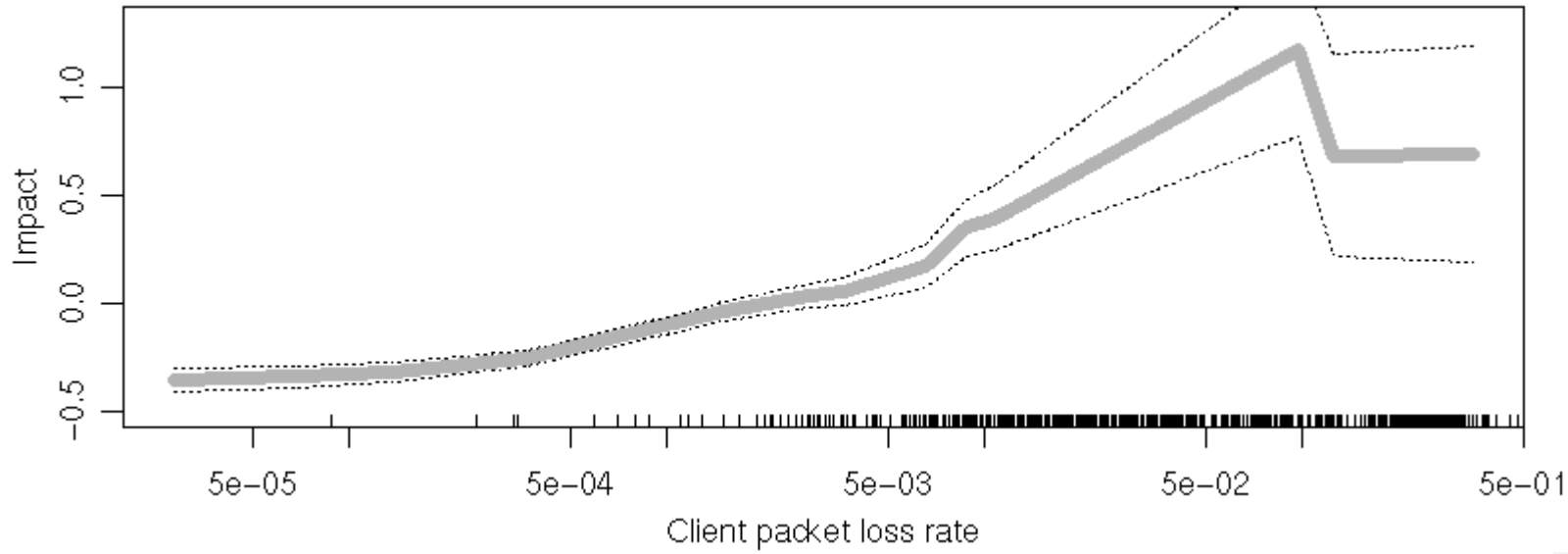
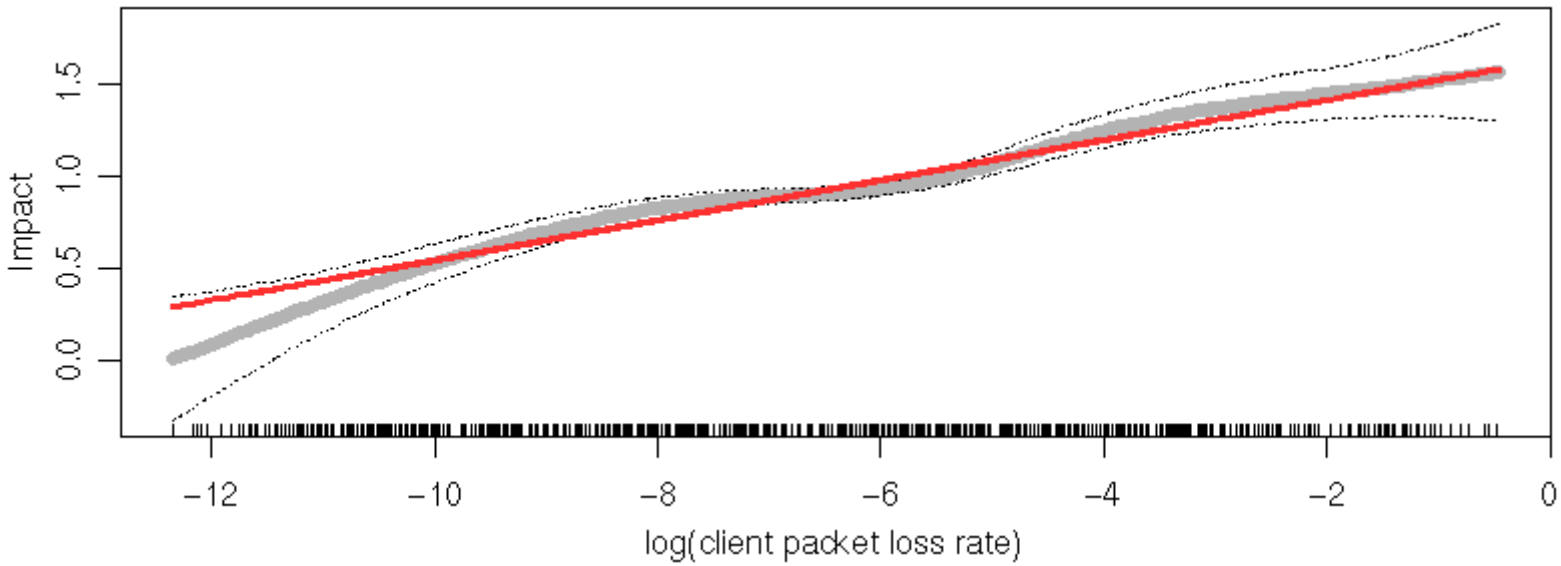
- All factors are better describing user departure rate in the logarithmic form

The Logarithm Fits Better (client packet loss rate)





Final Model & Interpretation

Variable	Coef	Std. Err.	Signif.
log(RTT)	1.27	0.04	< 1e-20
log(jitter)	0.68	0.03	< 1e-20
log(closs)	0.12	0.01	< 1e-20
log(sloss)	0.09	0.01	7e-13

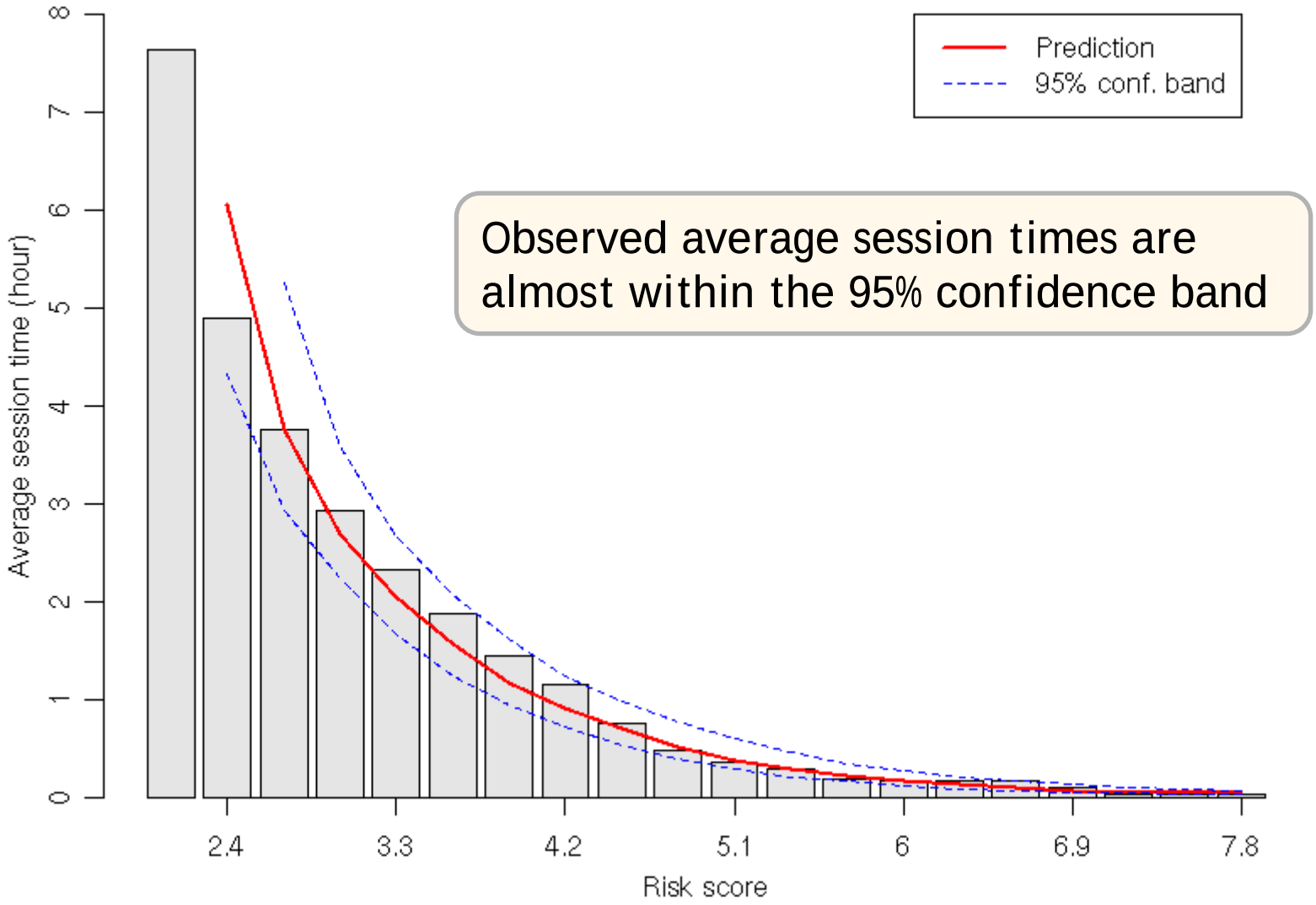
Interpretation

A: RTT = 200 ms
B: RTT = 100 ms, other factors same as A

Hazard ratio between A and B:
$\exp((\log(0.2) - \log(0.1)) \times 1.27) \approx 2.4$

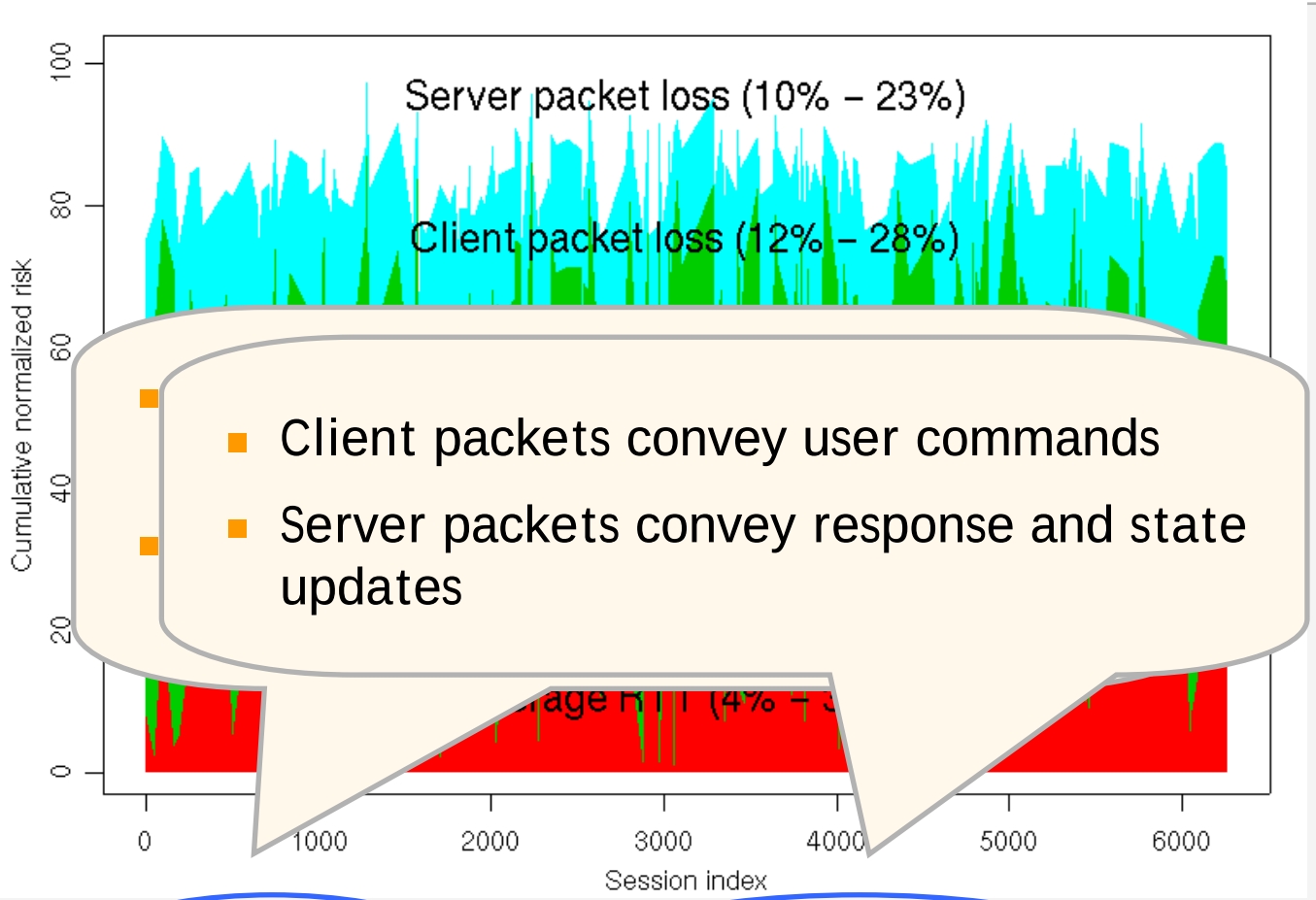
A will more likely leave a game (2.4 times probability) than B at any moment

How good does the model fit?



Observed average session times are almost within the 95% confidence band

Relative Influence of QoS Factors



- Client packets convey user commands
- Server packets convey response and state updates

Latency = 20%	Client packet loss = 20%
Delay jitter = 45%	Server pakce loss = 15%

Applications of the Time-QoS Model

- An index to quantify user intolerance of network quality:

$$\log(\text{departure rate}) \propto 1.27 \times \log(rtt) + 0.68 \times \log(jitter) + 0.12 \times \log(closs) + 0.09 \times \log(sloss)$$

- [Application 1] Optimizing user experience
  - Allocate more resources to players experience poor QoS
- [Application 2] Design tradeoffs
  - Is it worth to sacrifice 20ms latency for reducing 10ms jitters?
- [Application 3] Path selection

Path	Latency	Jitter	Loss rate	Risk
1	100 ms (G)	50 ms (P)	5% (P)	-5.6
2	150 ms (A)	20 ms (G)	1% (A)	-6.0
3	200 ms (P)	30 ms (A)	1% (A)	-5.4

(Best choice)

Summary

- Session time as a means to assess the impact of network quality on users in real-time applications
- Game players are not only sensitive, but also reactive, to network conditions they experience
- Proposed a time-QoS model as a utility function to optimize user experience and network infrastructure design

Thank You!

Kuan-Ta Chen