



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

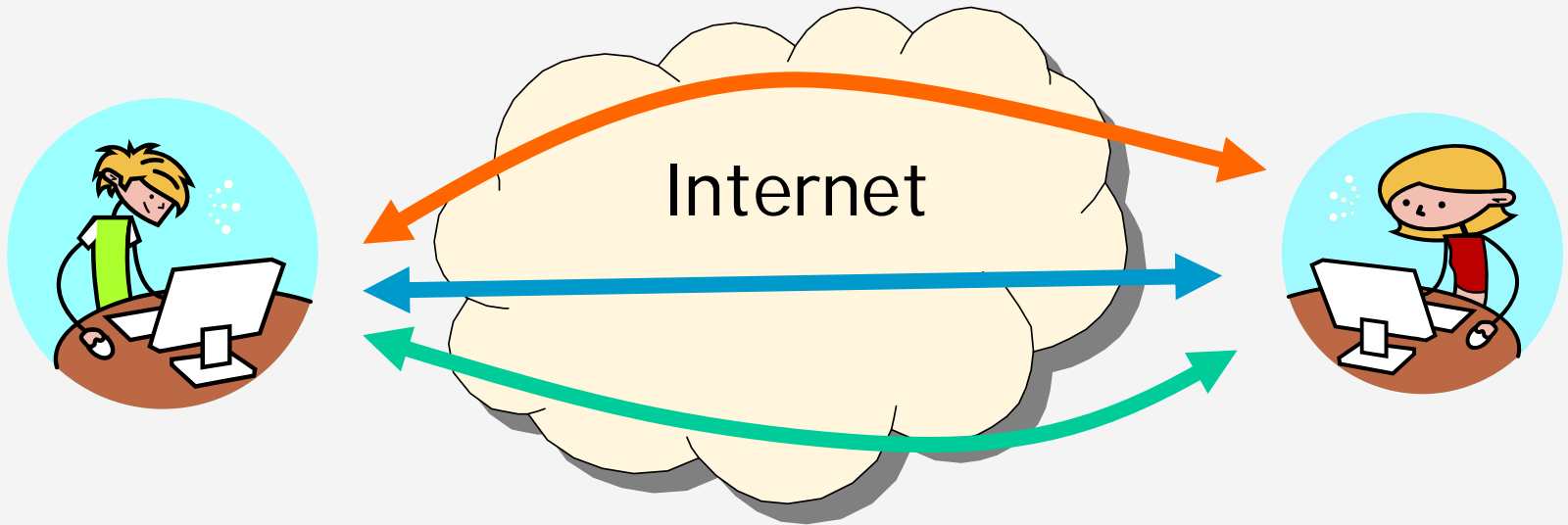
- Real-time interactive online games are generally considered **QoS-sensitive**
- Gamers always complain about high “ping-times” or network lags
- Online gaming is increasingly popular despite the best-effort Internet



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

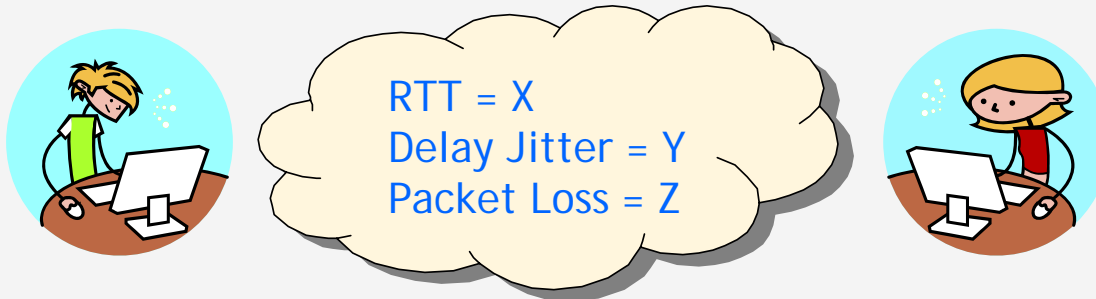


Which path can provide the best user experience?

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

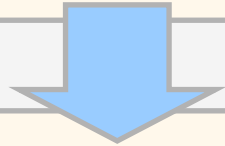


- Subjective evaluation is costly and not scalable
- Objective evaluation is not generalizable
 - Shooting games: number of kills
 - Racing games: time taken to complete each lap
 - Strategy games: capital accumulated

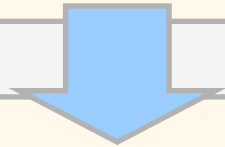
Real-life user behavior is not measurable in a controlled experiment

Our Conjecture

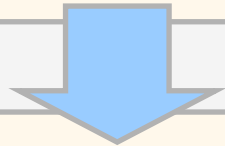
Poor Network Quality



Unstable Game Play



Less Fun



Shorter Game Play Time



affects

Verified by
real-life game
traces

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

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

神州 ONLINE

ShenZhou Online

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

神州城

姓名	小寬
職業	劍俠
名聲	無名小卒
生日	水曜日
負重	27 / 75

241 / 241

93 / 93

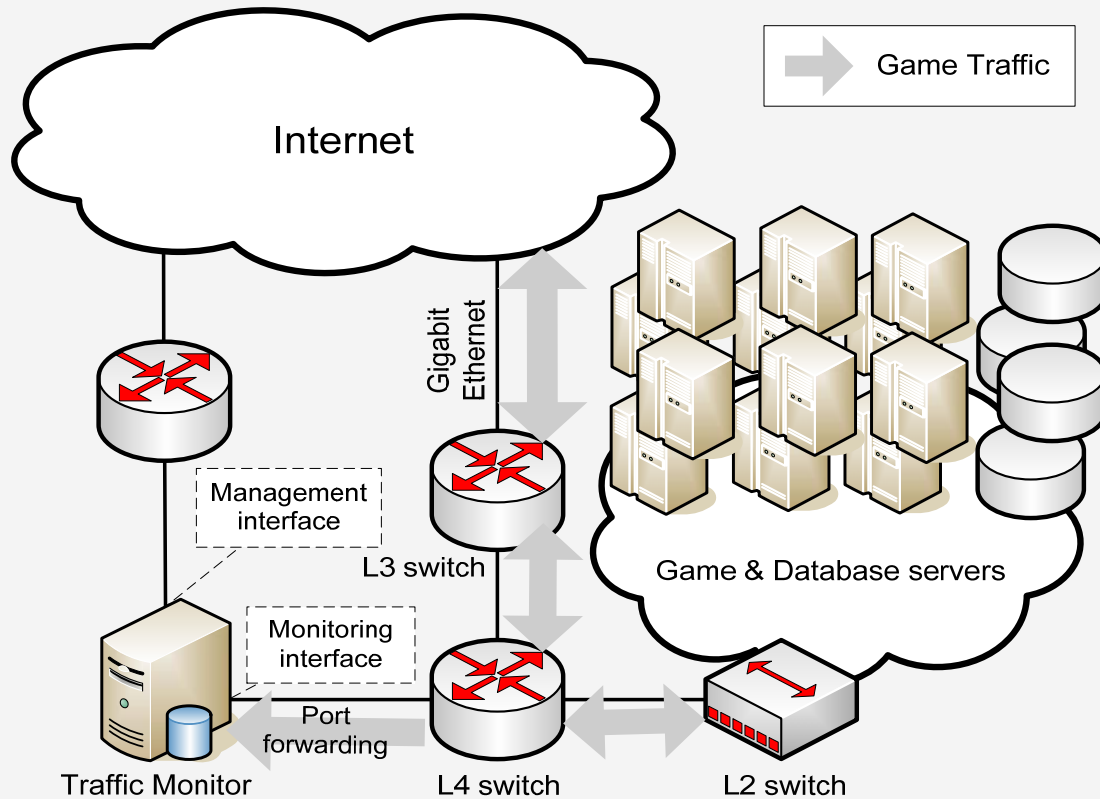
抓圖成功(cap\cap0059.jpg)◦
冰心雪>今天打蛇才賺為70萬
抓圖成功(cap\cap0060.jpg)◦
冰心雪>白鹿還死為一次
冰心雪>忘為看血 故看電視 QQ"
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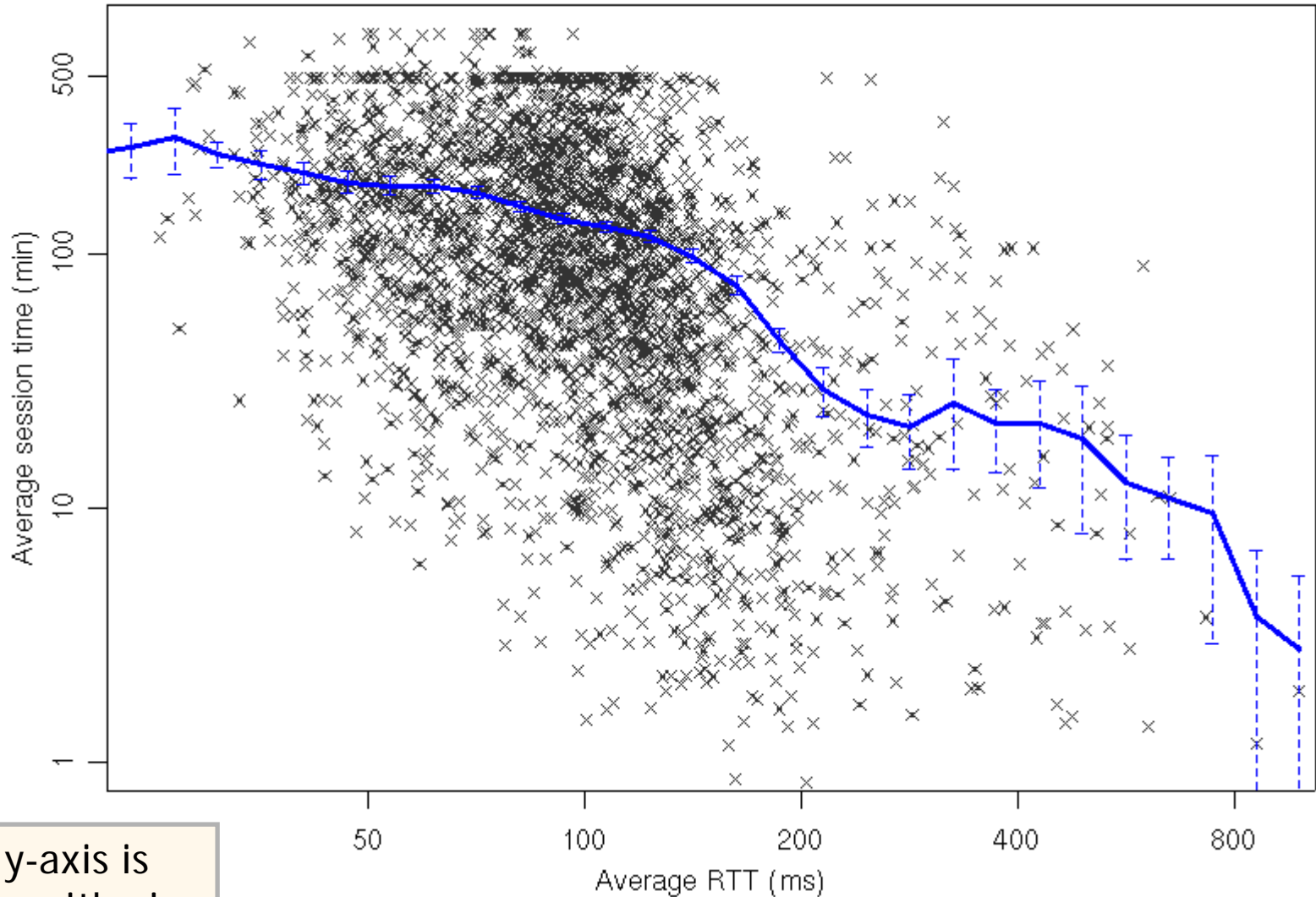
Trace Collection



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

(20 hours and 1,356 million packets)

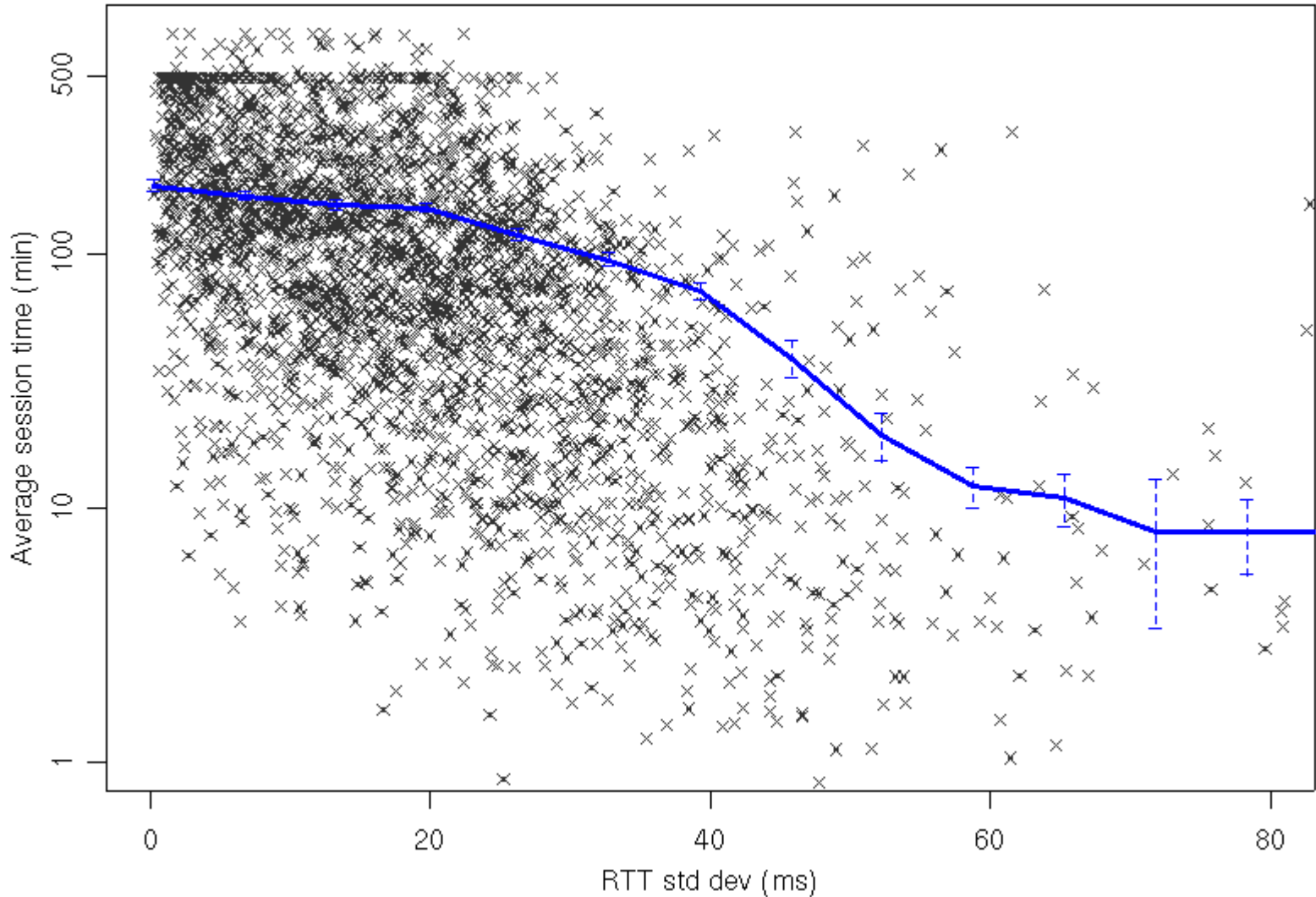
Round-Trip Times vs. Session Time



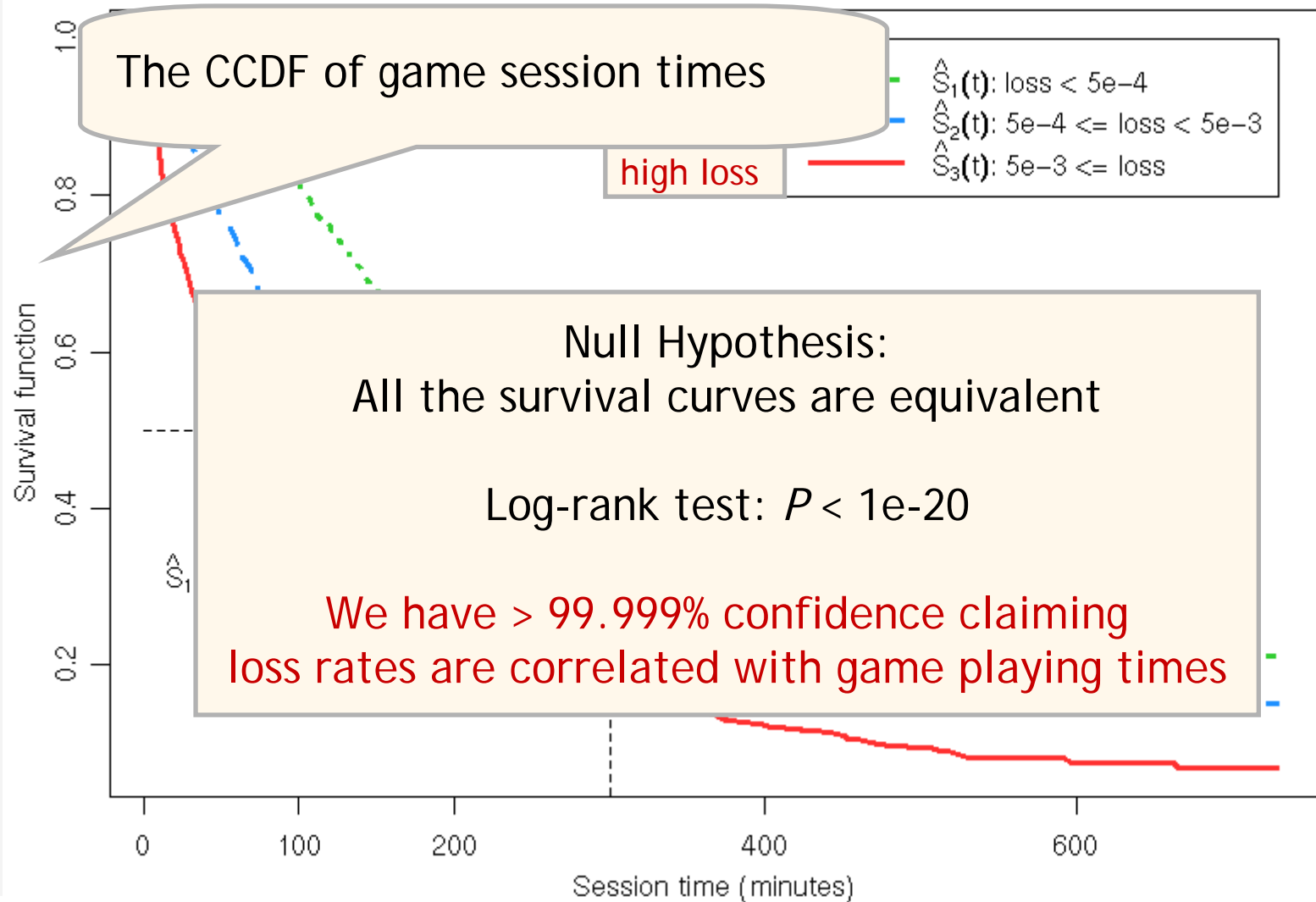
y-axis is
logarithmic

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

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

- Violating the assumptions (normal errors, equal variance, ...)

- The Cox regression model provides a good fit

- **Log-hazard function is proportional to the weighted sum of factors**

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

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

Hazard function (conditional failure rate)

The **instantaneous rate of quitting a game** for a player (session)

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

Model Fitting

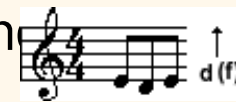
- $h(t|\mathbf{Z}_t) \propto \exp(\beta^t \mathbf{Z}_t)$ must be conformed

- 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. frequency)



- Star magnitudes (magnitude vs. brightness)

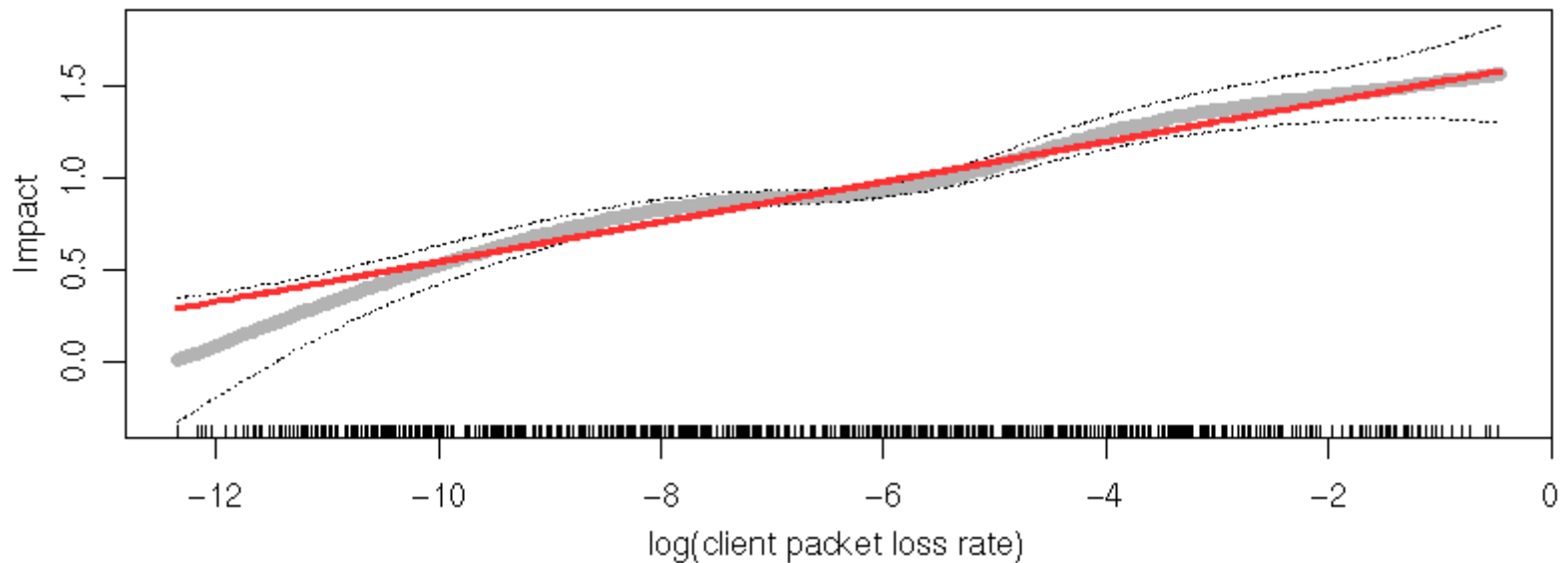
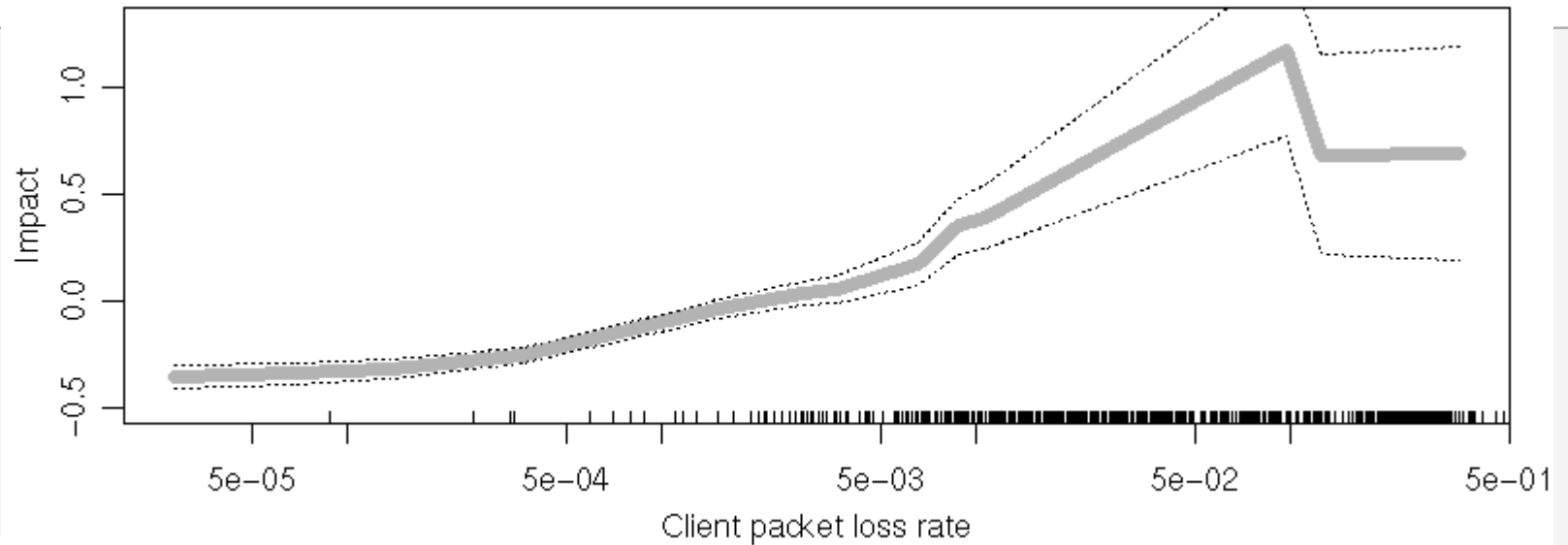


- All factors are better describing user departure rate in the **logarithmic** form

SS-

ept)

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

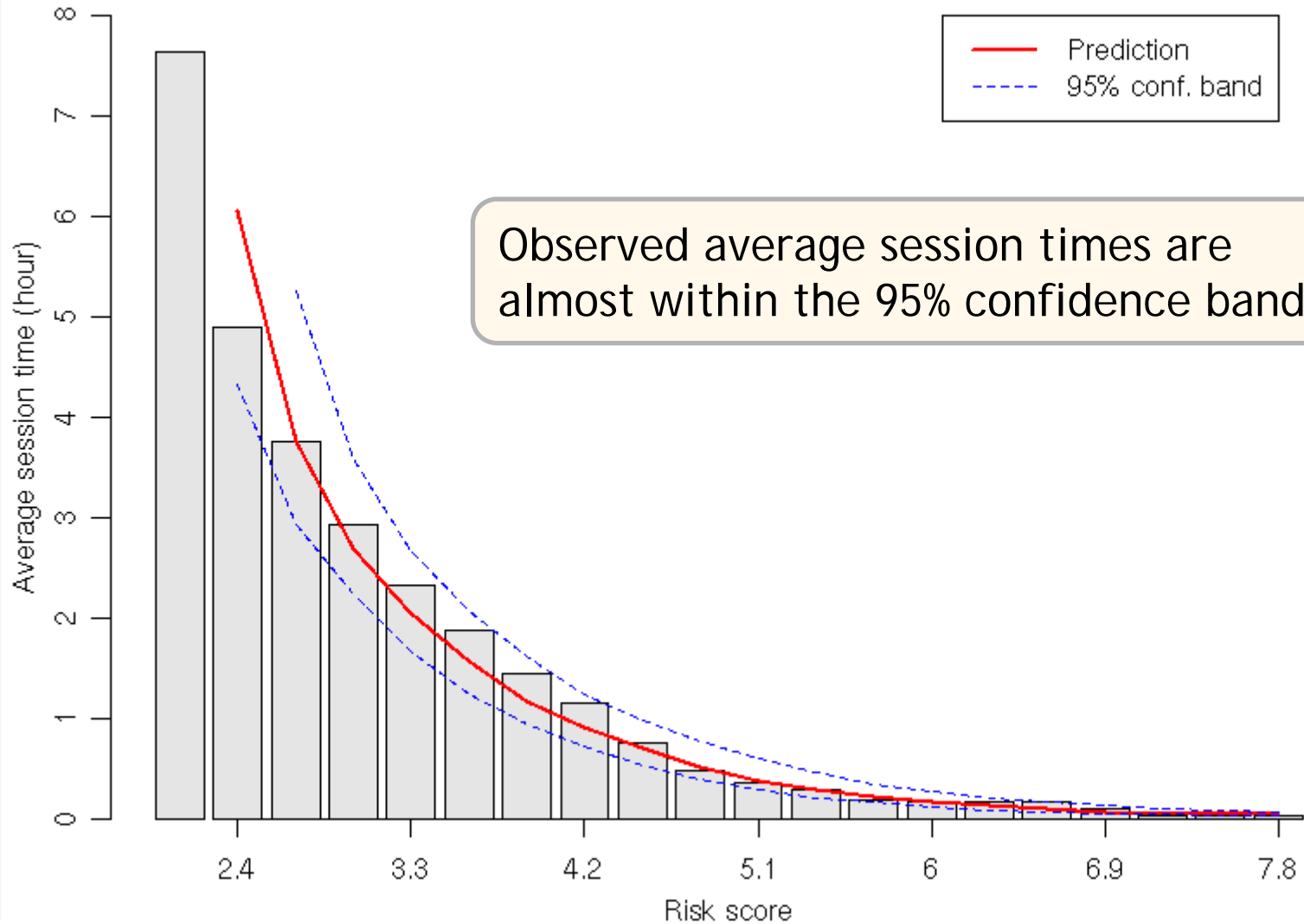
B: RTT = 100 ms, other factors same as A

Hazard ratio between A and B:

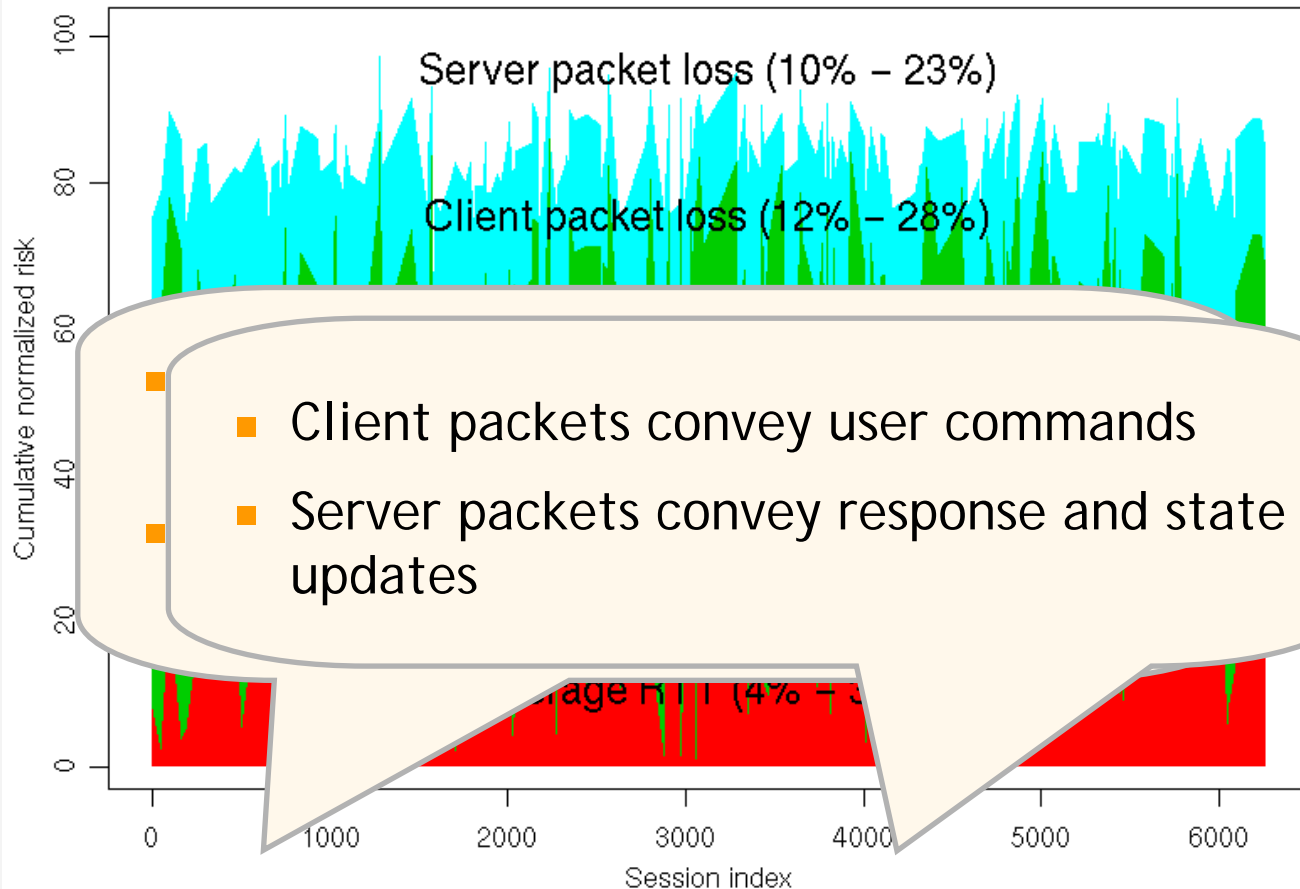
$$\exp((\log(0.2) - \log(0.1)) \times 1.27) \approx 2.4$$

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

How good does the model fit?



Relative Influence of QoS Factors



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