

Fairness in Multi-Player Online Games on Deadline-Based Networks

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Outline

- 1 Introduction
- 2 Unfair Scenarios in MOGs
- 3 Fairness Metrics
- 4 Fairness Strategies
- 5 Performance Evaluation
- 6 Conclusion

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Deadline-Based Networks

- Real-time applications: online auction, Internet telephony, interactive online game, etc.
- Delays: transmission, propagation, processing, and *queuing delays*

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- Delays: transmission, propagation, processing, and *queuing delays*
- Deadline-based networks:
 - Each Application Data Unit (ADU) is associated with a deadline
 - ADU deadlines are mapped to packet deadlines and carried in packets
 - Deadline-based scheduling is employed in routers
 - Reduce **queuing delays**

Fairness in Multi-Player Online Games

- Multi-player online games: World of Warcraft, Counter Strike, etc.
- Stringent requirement on delay performance

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 - Equal opportunity to win the game
 - Unfairness caused by differences among end-to-end delays

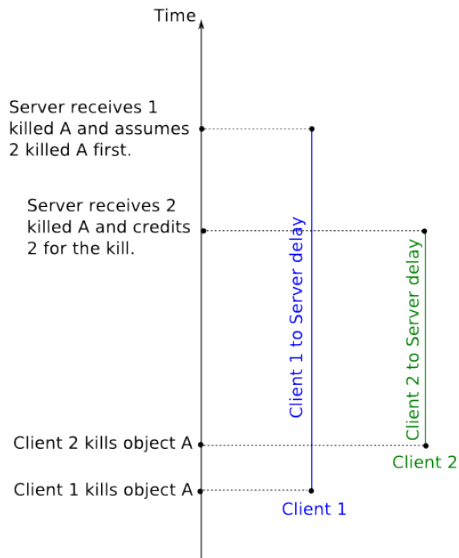
Fairness in Multi-Player Online Games

- Multi-player online games: World of Warcraft, Counter Strike, etc.
- Stringent requirement on delay performance
- Fairness:
 - Equal opportunity to win the game
 - Unfairness caused by differences among end-to-end delays
- Strategies: **network-based** and **delay-compensation**

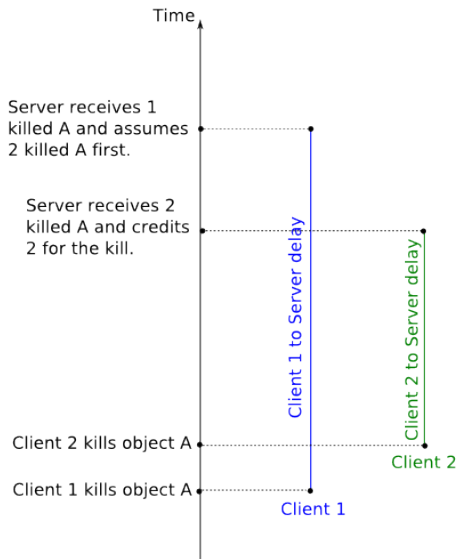
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Unfair Scenario 1 - Client to Server

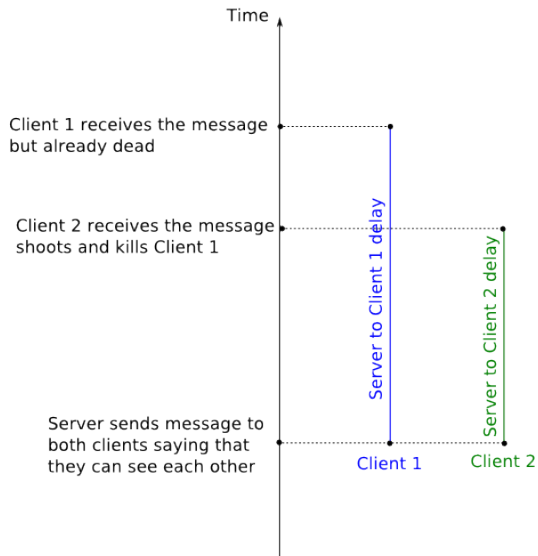


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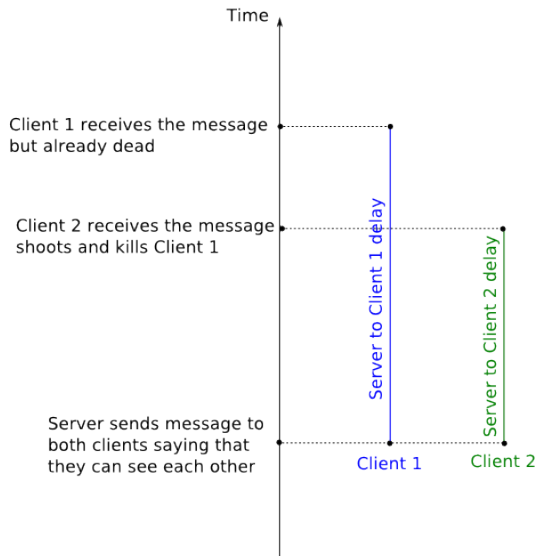


Unfair to client 1!

Unfair Scenario 2 - Server to Client



Unfair Scenario 2 - Server to Client



Unfair to client 1!

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Definition

A game session is said to be **fair** if:

- The *average* one-way delays of the packets sent from each *client to the server* are the same
- The *average* one-way delays of the packets sent from *the server to each client* are the same

Fairness Metric for Client-to-Server Traffic (1/2)

- n : number of clients
- $(d_i)_k$ ($i = 1 \dots n$): end-to-end delay of packet k from client i to the server
- m_i : number of packets sent from client i to the server
- θ_i ($i = 1 \dots n$): average end-to-end delay of all the packets sent from client i to the server

$$\theta_i = \frac{\sum_{k=1}^{m_i} (d_i)_k}{m_i}$$

Fairness Metric for Client-to-Server Traffic (2/2)

- ϵ : average end-to-end delay of all packets sent from *all the clients* to the server

$$\epsilon = \frac{\sum_{i=1}^n \theta_i}{n}$$

- δ_i ($i = 1 \dots n$): absolute value of the difference between θ_i and ϵ

$$\delta_i = |\theta_i - \epsilon|$$

- **Fairness index 1**, denoted by \mathbf{F}_1

$$\mathbf{F}_1 = \sum_{i=1}^n \delta_i$$

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Strategy to Reduce F1: Delay-Compensation

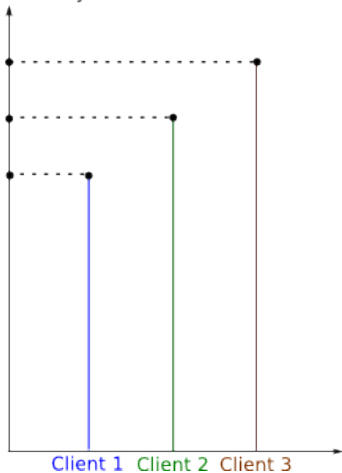
- In the interval I_{j+1} , extra delays are added to the packets sent from clients **who have the average delay θ_i 's lower than the total average delay ϵ** in the interval I_j
- Amount of delay added is: $\epsilon - \theta_i$ ($i = 1 \dots n$)

Strategy to Reduce F1: Network-Based

- In the interval I_{j+1} , deadlines of the packets sent from clients, **who have the average delay θ 's larger than the total average delay ϵ** in the interval I_j , are adjusted *downwards*
- New end to end deadline must be larger than (total transmission delay + total propagation delay)

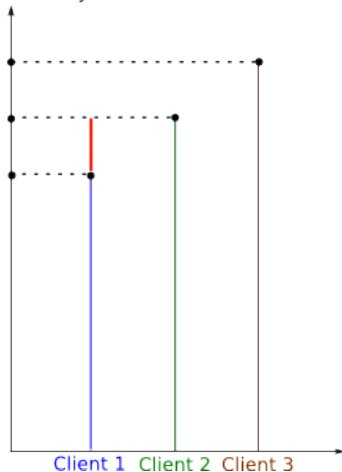
Strategies Illustration

Average Client-to-Server
End-to-End delay



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Average Client-to-Server
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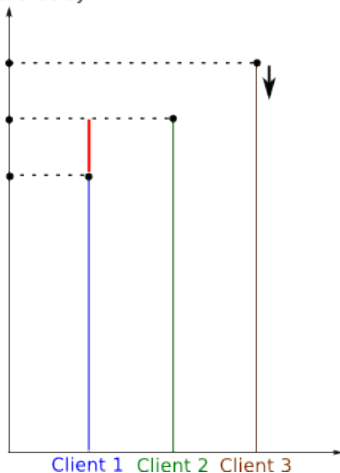


In the next interval:

- 1 Delay-Compensation: Add extra delays

Strategies Illustration

Average Client-to-Server
End-to-End delay



In the next interval:

- 1 Delay-Compensation: Add extra delays
- 2 Network-Based: Use more urgent deadlines

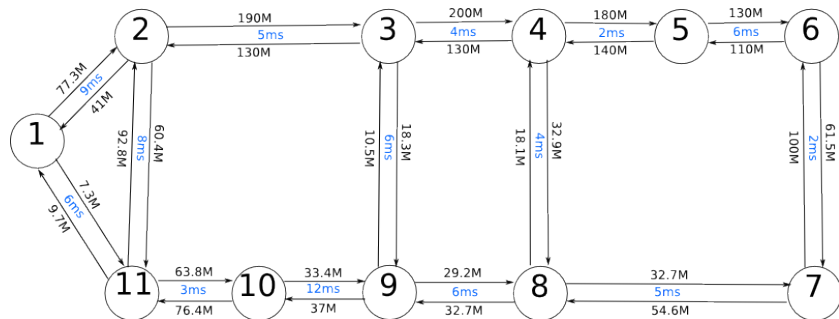
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Performance Model

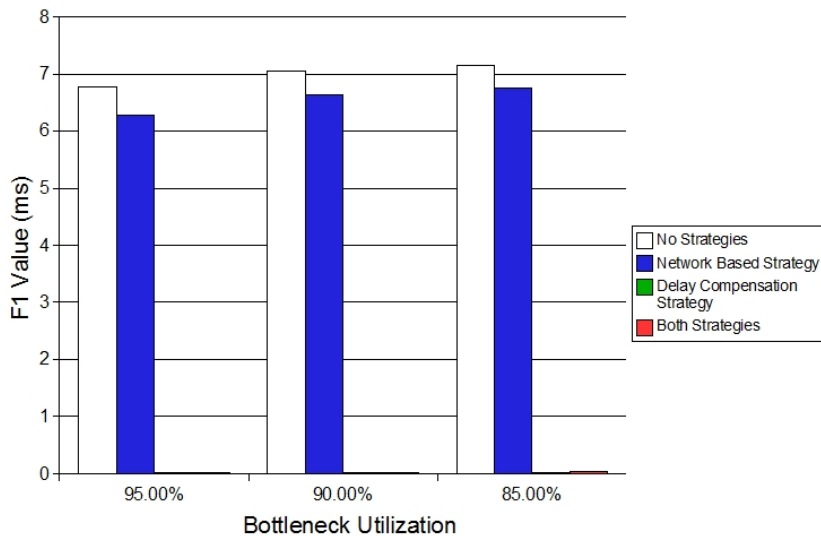
- Discrete event simulation model developed in Java
- Network model: a scaled down version of Abilene backbone network (<http://abilene.internet2.edu/>)
- Traffic model: foreground first person shooter (FPS) game, background FPS game, music, movie

Network Model

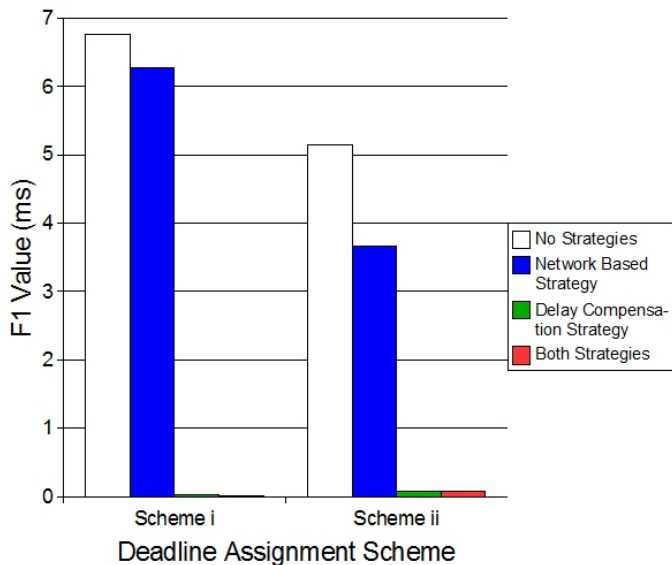


- 1 Seattle
- 2 Denver
- 3 Kansas
- 4 ...

Effect of Network Load on F1



Effect of Deadline Assignment Scheme on F1



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Conclusion

- Fairness in MOGs is defined
- Fairness metrics are introduced
- Both **Delay-Compensation** and **Network-Based** strategies can improve fairness significantly
- Delay-Compensation can be used on current network
- Network-Based requires Deadline-Based network