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# ***A Comprehensive End-to-End Lag Model for Online and Cloud Video Gaming***

Florian Metzger, Albert Rafetseder, Christian Schwartz ■ 2016/08/29

*Modeling of Adaptive Systems*

<https://www.mas.wiwi.uni-due.de/en>

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CS:GO gameplay at 30fps (normally played at 120+)

clip extracted from <https://www.youtube.com/watch?v=02I5vVx1JhU>

same clip at 6fps

clip extracted from <https://www.youtube.com/watch?v=02I5vVx1JhU>

- Increasing research interest for (networked) video game QoS and QoE
- Increasing focus on and demands of **competitive games**
- But many past endeavors treated video games similar to video streaming and faced issues
  - Insufficient framerates (actual examples: 3 Hz, 7 Hz, 15 Hz)
  - Wrong choice of metrics (e.g. time-scale wise)
  - Studies focused only on network delay, not E2E lag
  - Observation periods too short
  - No understanding of core gameplay mechanics
  - Cannot generalize results from individual games to a whole “genre”
- Many interlocked mechanics in play
- Need for a better understanding of these mechanics
- Looking only at authoritative client/server games here, not peer-to-peer

## Framerate and Frametime

Rate at which the game renders distinct images. Frametime is the time between two such images.

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## Tickrate

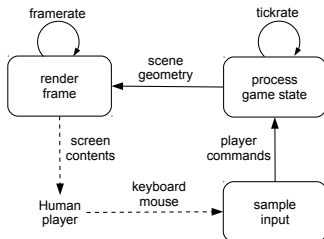
Rate at which the server in a client/server-game updates its game simulation state.

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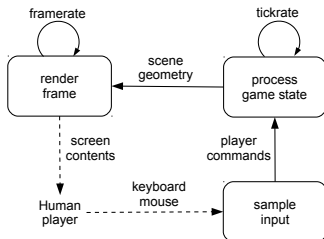


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Framerate constraints:

- Motion perception in video: Based on principle of apparent motion according to [Wer12] starting at a min. frame rate of 16 Hz
- But framerate and tickrate are also governing factors for input latency
- Common game frame rates: 30 Hz, 60 Hz, 120 Hz, 144 Hz





# Information Deficit through Low Framerate

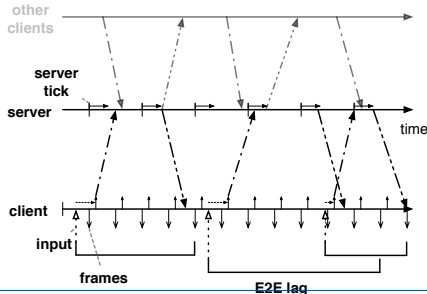
Low framerates are a source of lag

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<http://blog.logicalincrements.com/2015/04/does-fps-matter-decide-for-yourself/>

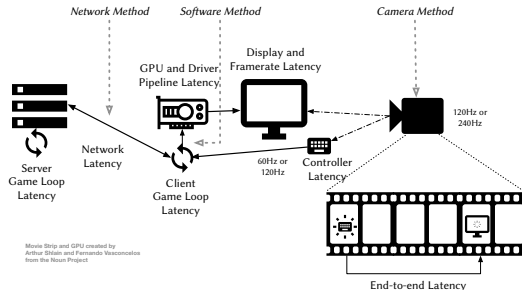
- Perceived delay or inconsistency from an input action to the reaction
- Caused by various latency sources, e.g. network QoS, I/O devices, game engine, game mechanics
- But also through the interplay of Sometimes caused by game mechanics
- Examples of tickrates in c/s-games: CS:GO 64 Hz to 128 Hz; Dota 2 30 Hz; Overwatch 60 Hz
- Command message and client update message rates may also differ from tick- and framerate



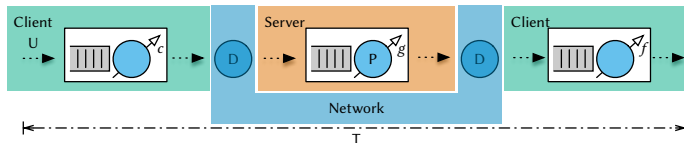
- Lag affects reaction and timings, gameplay, player performance

⇒ potentially largest **QoE** influencer

- Every game is influenced differently by lag and exhibits a distinct lag profile
- Different viewpoints observe different lags, full E2E lag can only be captured externally



- End-to-End lag sources modeled as a queuing system
- Goal: investigate alternate lag sources not typically attributed to lag: frame- and tickrate, message rates, input and display devices
- Critical factor: interaction of multiple, independently clocked processes

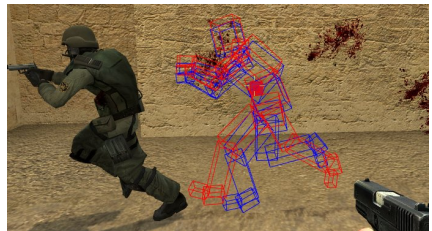


- Implemented as R simulation<sup>1</sup>
- Evaluated for several scenarios and parameter combinations

<sup>1</sup><https://github.com/mas-ude/onlinegame-lag-sim>

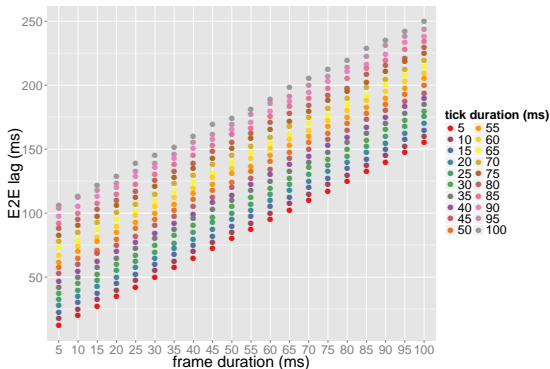
Features that can reduce lag impact in games, not considered in the model

- Immediate visualization through client-side prediction of object actions (e.g. player movement) (without waiting for authoritative answer)
- Visualization interpolation between snapshots  
// extrapolation from last two server game state snapshots
- Lag compensation by doing hit detection on object positions slightly in the past



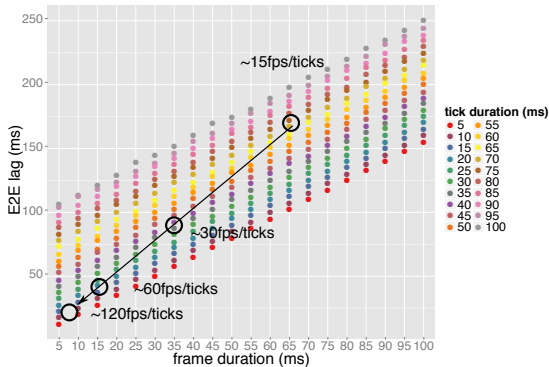
[developer.valvesoftware.com/wiki/Lag\\_compensation](http://developer.valvesoftware.com/wiki/Lag_compensation)

Locally running C/S-game, no network interactions involved.



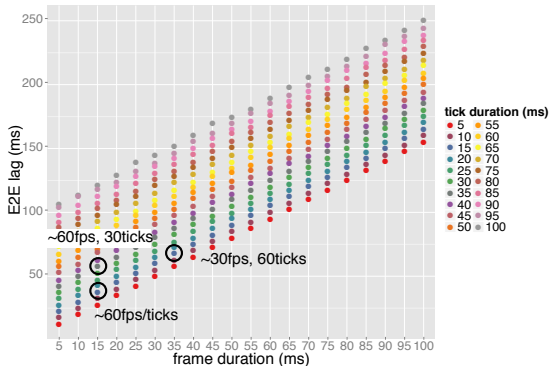
(Note 16.67 ms frame duration  $\hat{=}$  60 Hz framerate)

Locally running C/S-game, no network interactions involved.



Linear decrease of E2E lag!

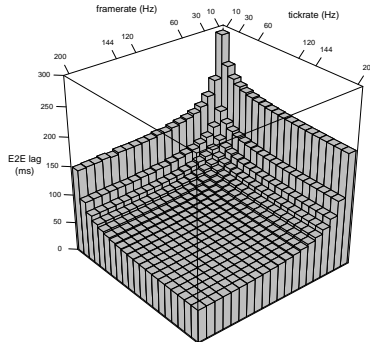
Locally running C/S-game, no network interactions involved.



Bigger impact of framerate than tickrate!

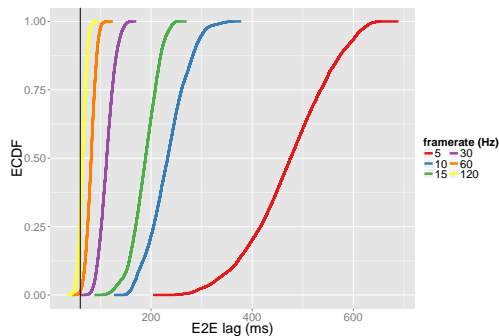


Networked game at 10 Hz to 200 Hz frame- and tickrates;  
median of 1000 rounds for each bar; 40 ms base network RTT



negligible network influence at low frame-/tickrates

Similar to networked C/S but with added video en-/decoding delay and frame transmission times  
(Vertical line denotes average base networking and en-/decoding delay)



Large E2E lag and (more importantly) broad spread of lag values  
⇒ input actions are experienced as “stuttering”

- Simplified simulation of typical gaming scenarios
- Complex scenario due to interactivity and diversity of video games
- Reexamine and focus on framerates as a large QoE factor
- Larger influence of framerates than generally accepted

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In the future:

- More extensive simulation setup with more influence factors
- Derive guidelines for future user studies

# Questions?

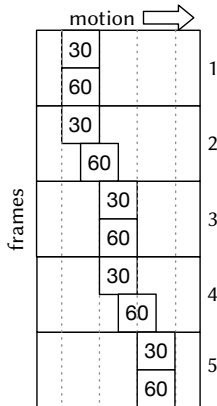
<https://github.com/mas-ude/onlinegame-lag-sim>

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Key fingerprint: C98A 32B7 554F C5CC 4E5A 60FB 1CE5 B541 7B20 99C7



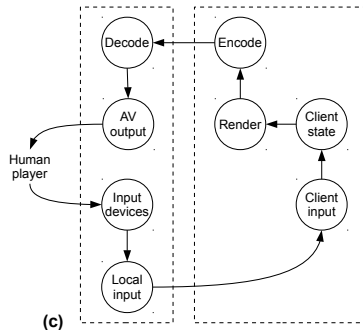
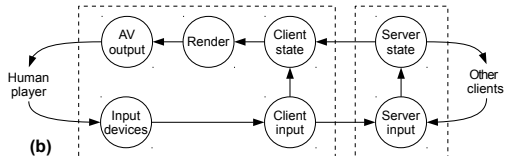
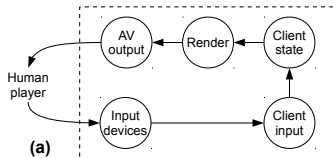
## Backup Slides





# Alternate Framerate Animation Backup





(a) local game, (b) networked game, (c) cloud game

Command message rates and client update rates can differ from server tickrates

Video Game	Tickrate
CS: GO	Configurable 64 Hz/128 Hz
Battlefield 4	Configurable 60 Hz/120 Hz; previously 30 Hz with 10 Hz for state outside of close proximity
Minecraft	max. 20 Hz
League of Legends	30 Hz
Dota 2	30 Hz
StarCraft II	supposedly either 16 Hz or 32 Hz
Eve Online	1 Hz
Overwatch	60 (client update rate previously was 20)

Note: Values are considered to be unofficial and may be unreliable



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