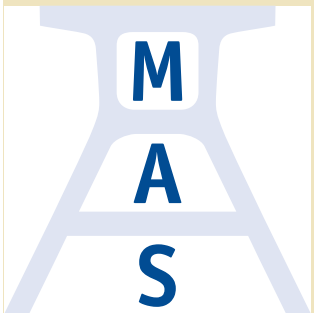

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A Comprehensive End-to-End Lag Model for Online and Cloud Video Gaming

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

Modeling of Adaptive Systems

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

Games and Frames

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

clip extracted from `https://www.youtube.com/watch?v=02I5vVxlJhU`

same clip at 6fps

clip extracted from `https://www.youtube.com/watch?v=02I5vVxlJhU`

Motivation and Past Issues

- 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.

Frame- and Tickrates

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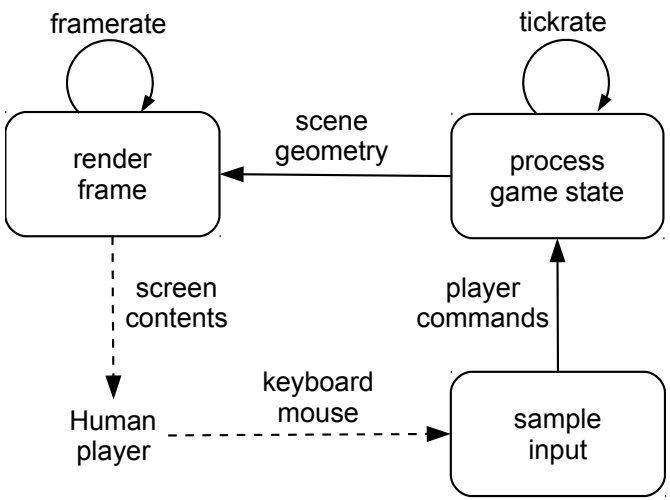

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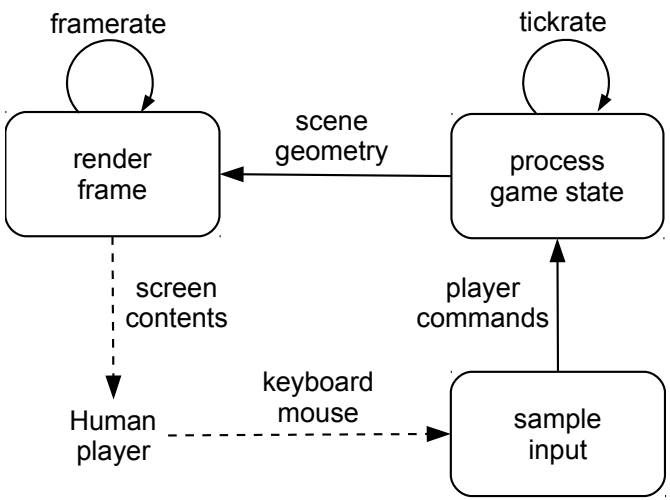


Framerate constraints:

- 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

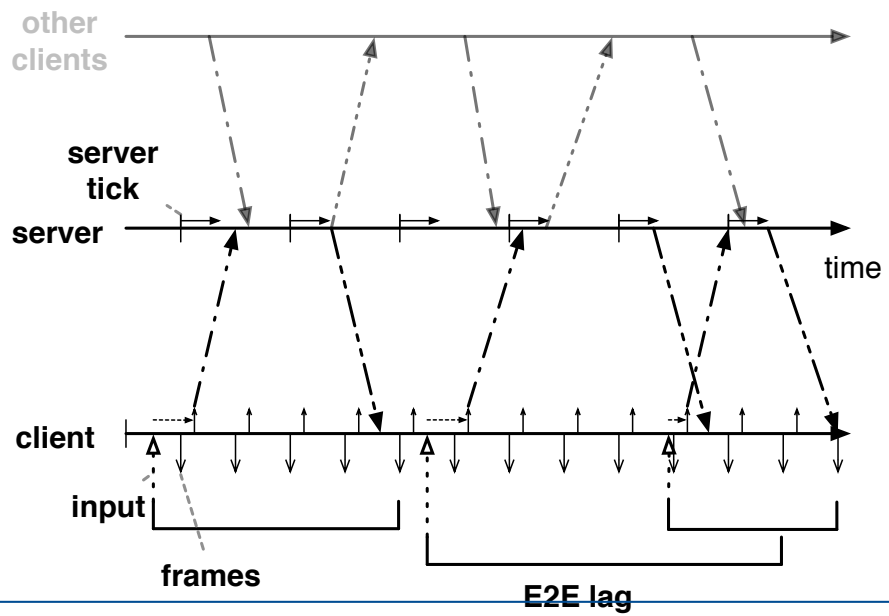
Information Deficit through Low Framerate

Low framerates are a source of lag

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

What is End-to-End Lag?

- 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

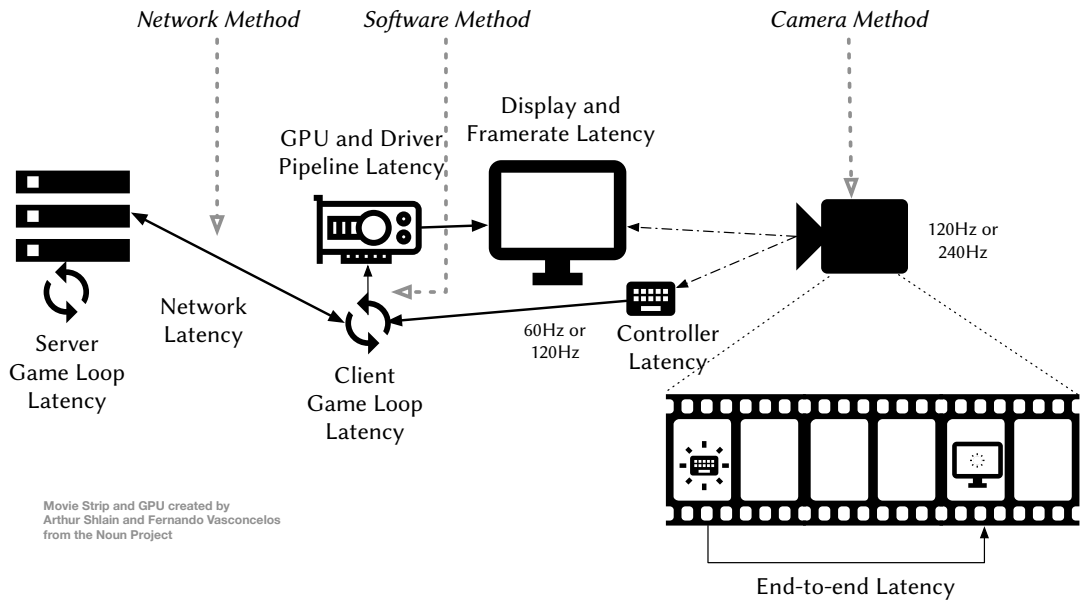


Attributes and Measures of Lag

- Lag affects reaction and timings, gameplay, player performance

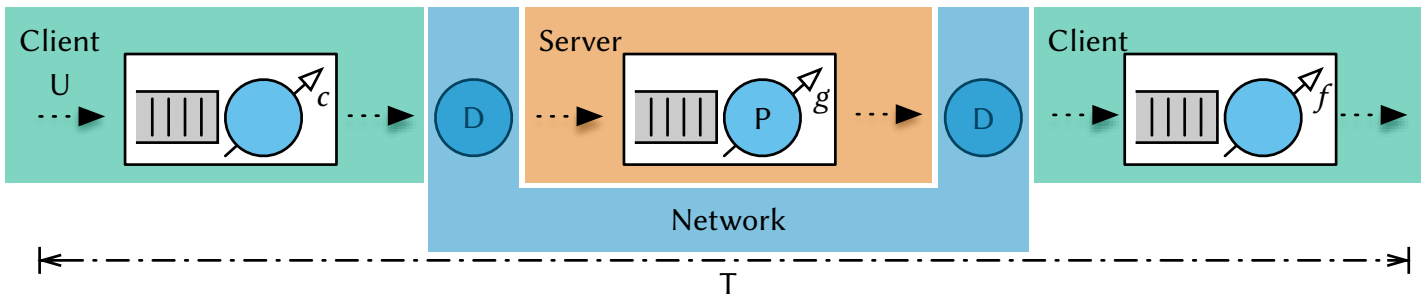
⇒ potentially largest **QoE** influencer

- 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



Modeling and Simulating Lag

- 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



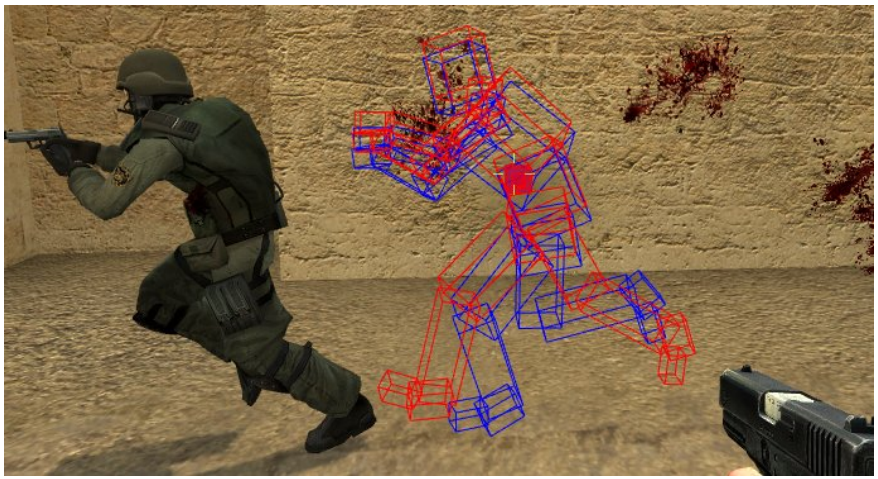
- Implemented as R simulation[1]
- Evaluated for several scenarios and parameter combinations

[1] `https://github.com/mas-ude/onlinegame-lag-sim`

Model Limitations and Caveats: Lag-Concealing Features in Games

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

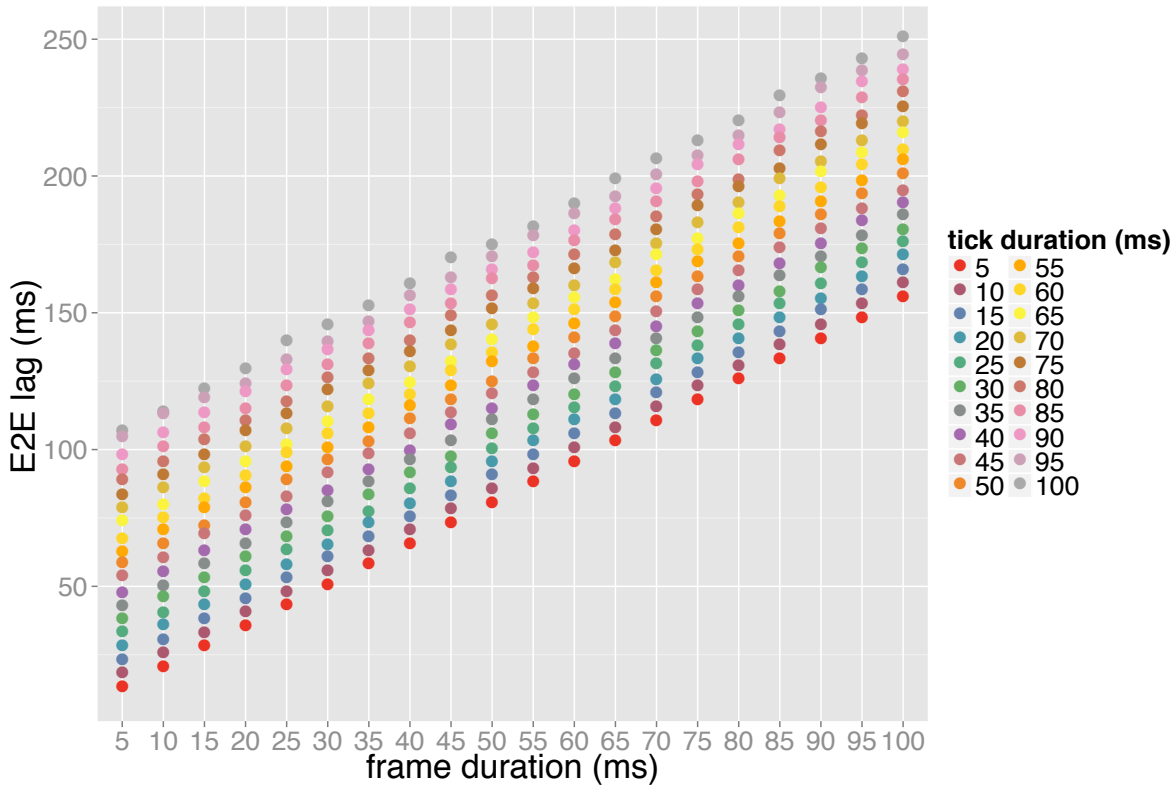


developer.valvesoftware.com/wiki/Lag_compensation

Local Game Simulation

A.K.A.: Best Case Lag Scenario

Locally running C/S-game, no network interactions involved, average of 1000 runs.



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

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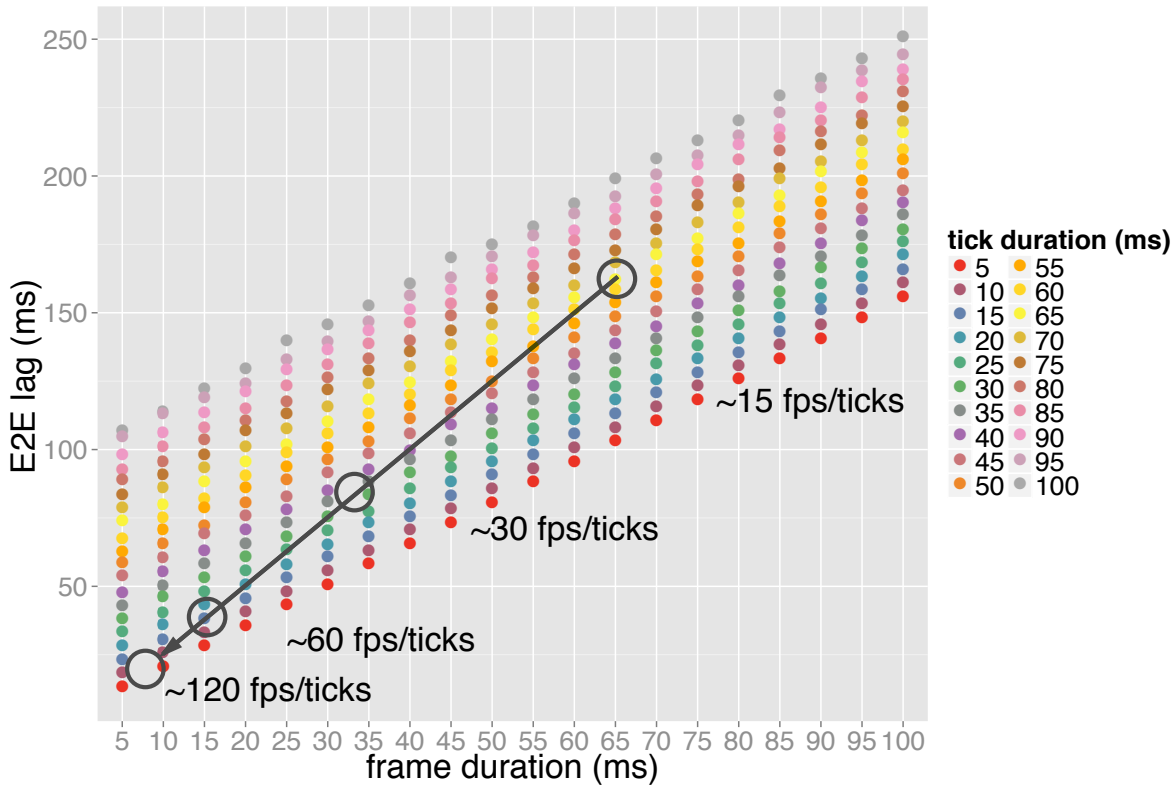

Linear decrease of E2E lag; 50 ms less going from 30 to 60.

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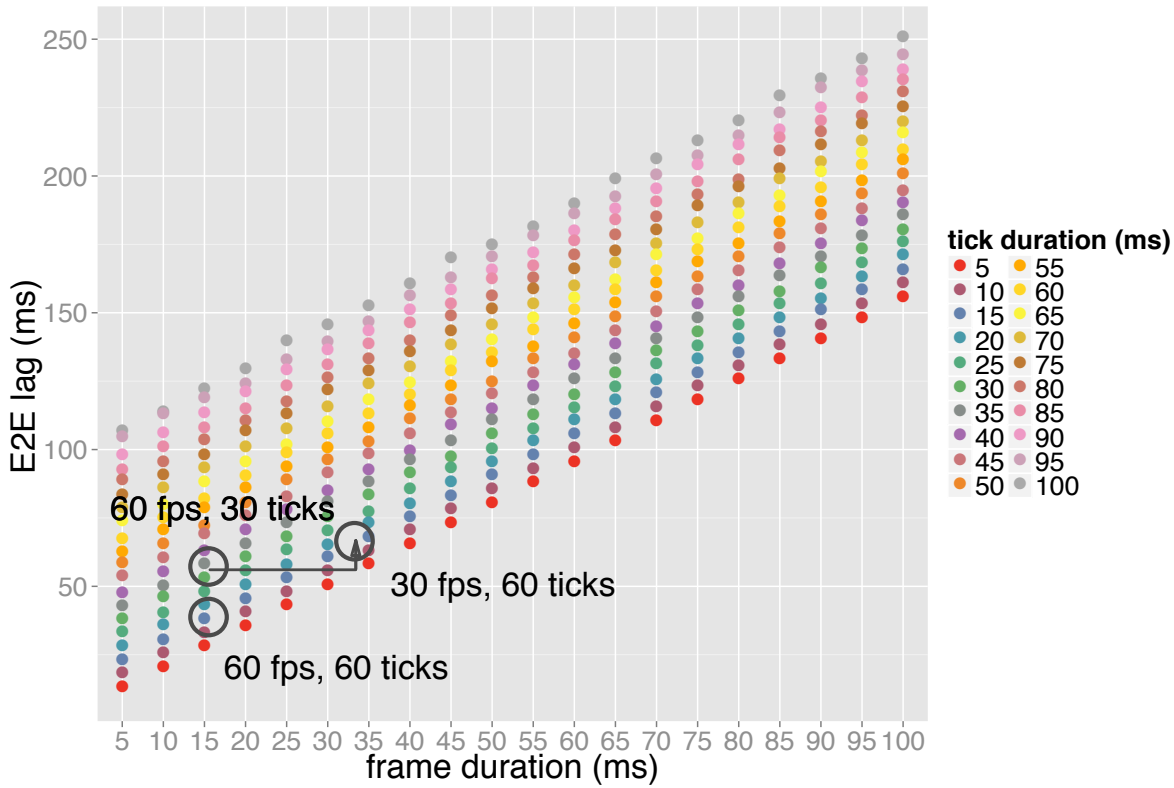
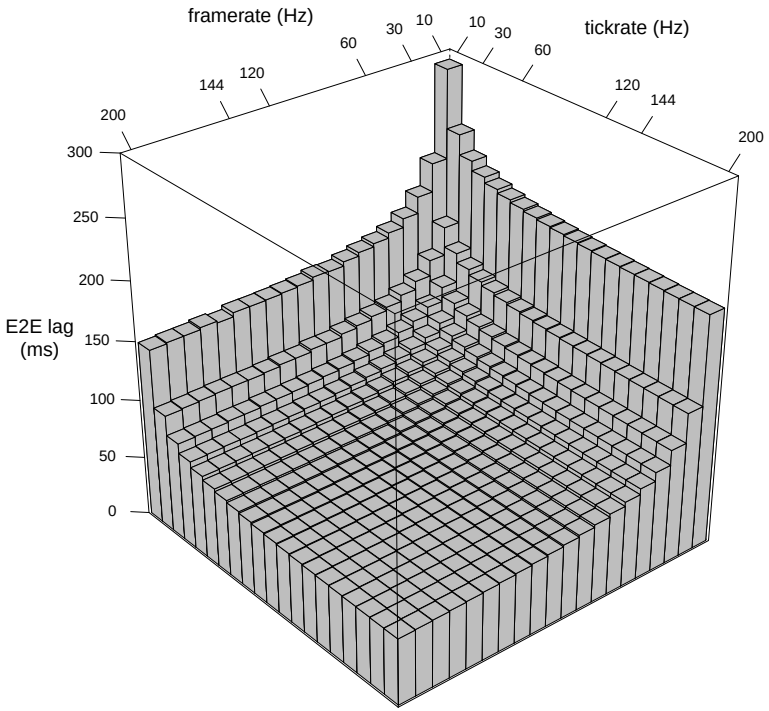


Bigger impact of framerate than tickrate!

Networked Game Simulation

Networked game at 10 Hz to 200 Hz frame- and tickrates;

median of 1000 rounds for each bar; 40 ms base network RTT

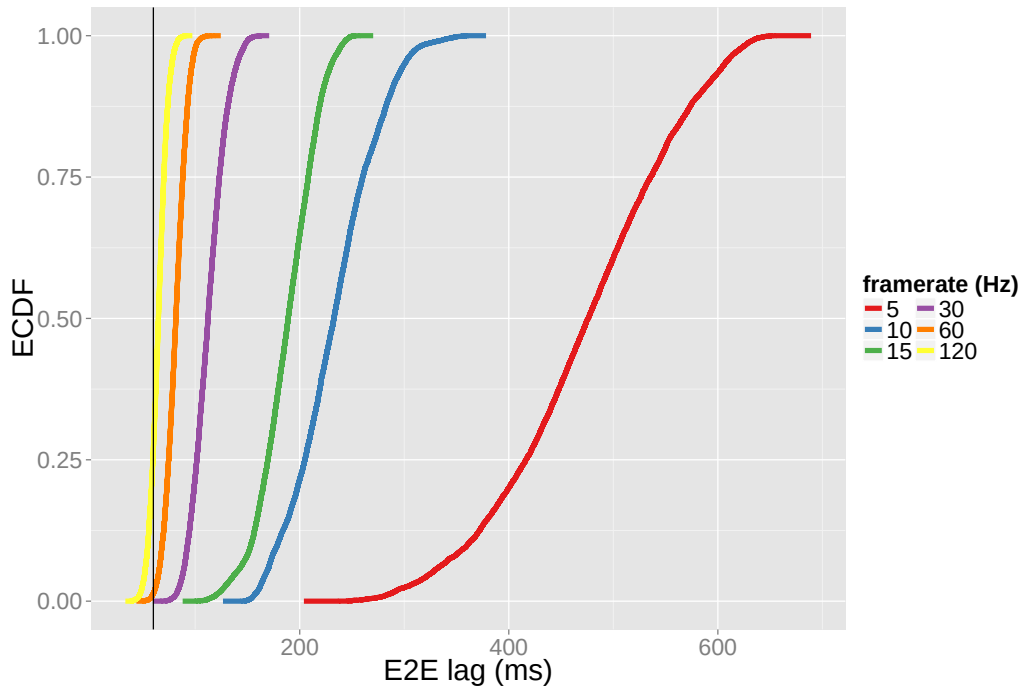


negligible network influence at low frame-/tickrates

Cloud Game Simulation

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

$\Rightarrow$ input actions are experienced as “stuttering”

Conclusions

- 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

Thanks!

Questions?

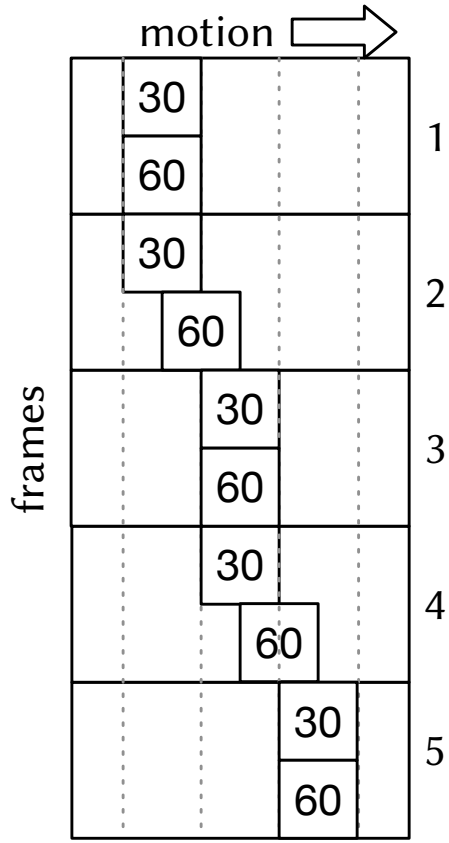
https://github.com/mas-ude/onlinegame-lag-sim

Contact: florian.metzger@uni-due.de

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

Backup Slides

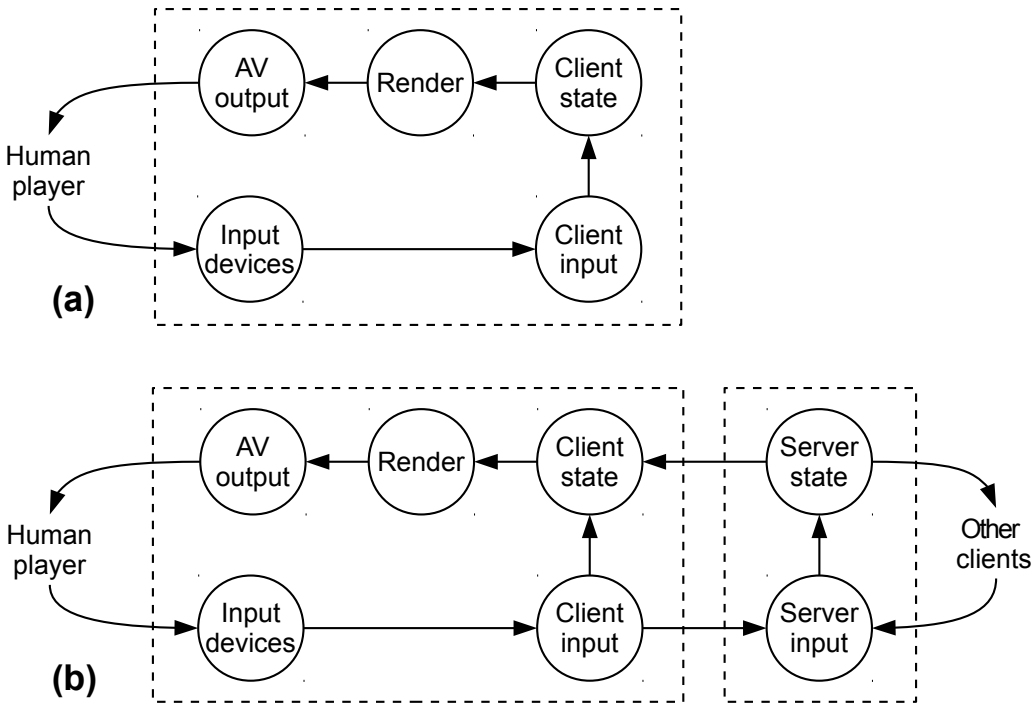
Static Framerate Figure Backup



Alternate Framerate Animation Backup

http://hugelol.com/lol/364250

Simplified Video Game Main Loops



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

Tickrates in Video Games

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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