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Open-Minded

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

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

clip extracted from `https://www.youtube.com/watch?v=02I5vVxlJhU` same clip at 6fps

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Motivation and Past Issues

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  - Wrong choice of metrics to detect influence of lag (e.g. time-scale wise)
  - Focus just on network delay, not full E2E lag
  - Observation periods too short
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  - Inability to generalize results from individual games to whole "genres"
- Many interlocked mechanics in play, we need to understand their effects!

$\Rightarrow$ Set up a small sim to to get some rough numbers

Framerate and Frametime

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

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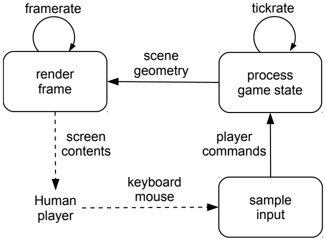

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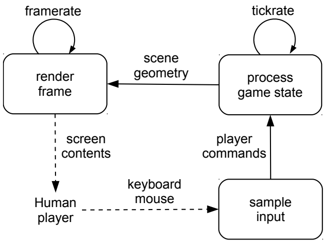

Framerate constraints:

- 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

What is End-to-End (E2E) Lag?

- Perceived delay and delay variation between input action and visible reaction
- Caused by various latency sources, e.g. network QoS, I/O devices, game engine, game mechanics
- But also through the interplay of framerate and tickrate
- Examples of tickrates in c/s-games: CS:GO 64 Hz to 128 Hz; Dota 2 30 Hz; Overwatch 60 Hz

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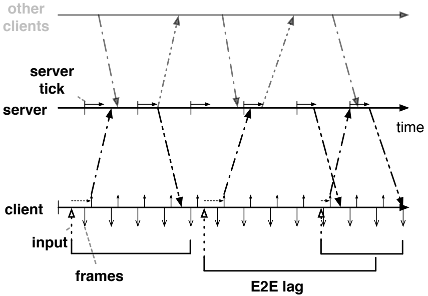

http://blog.logicalincrements.com/2015/04/does-fps-matter-decide-for-yourself/

Attributes and Measures of Lag

- Lag affects reaction and timings, gameplay, player performance

$\Rightarrow$ Potentially largest **QoE** influencer

- Every game, every gameplay action, can behave differently under lag
- Different viewpoints to observe lag, but full E2E lag can only be captured externally

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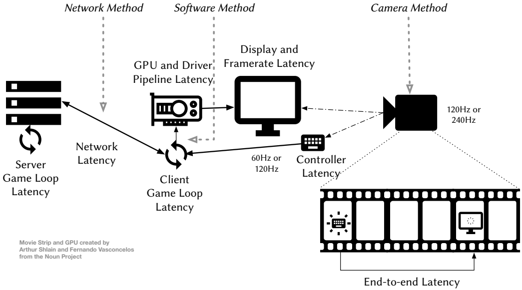

- Lag sources modeled in a queuing system
- Goal: investigate lag sources not typically attributed to lag
- Especially: frame- and tickrate; but also: message rates, input and display devices
- Frame- and tickrate modeled as independently clocked processes

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

Modeling and Simulating Lag

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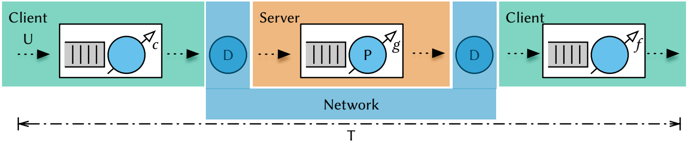

- Implemented as R simulation[1]
- Evaluated for several scenarios and parameter combinations

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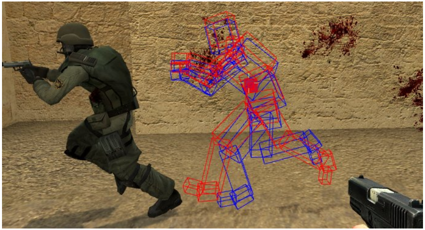
Examples of features that can reduce lag impact in games, but are not considered in the model and sim:

- Immediate visualization and output of object actions through client-side **prediction** (e.g. player movement) without waiting for authoritative answer
  - Roll back action if prediction wrong
- **Interpolate** motion between consecutive game simulation snapshots from the server, or extrapolate from last two snapshots
- Lag **compensation** by doing hit detection on object positions slightly in the past

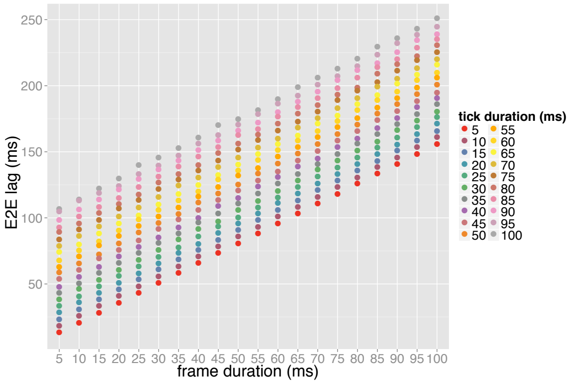


developer.valvesoftware.com/wiki/Lag_compensation

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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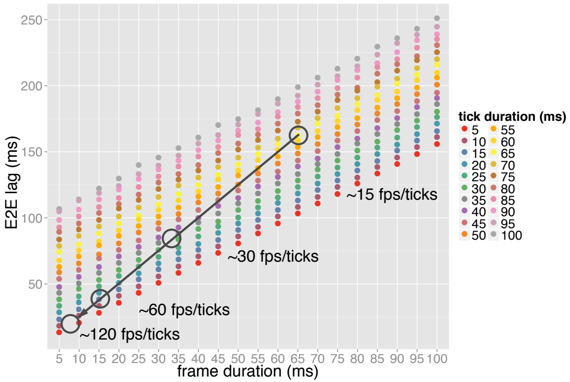
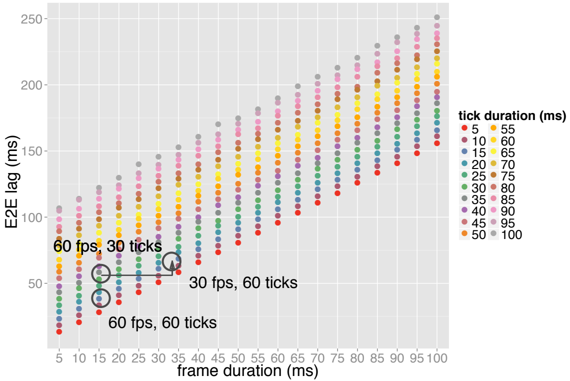


Linear decrease of E2E lag; 50 ms less going from 30 to 60.

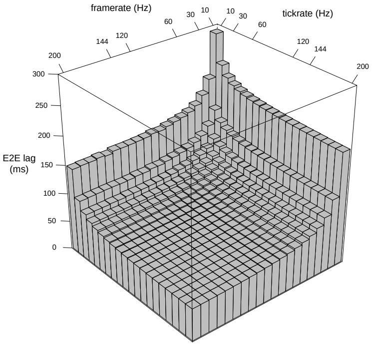
Locally running C/S-game, no network interactions involved, average of 1000 runs.



Bigger impact of framerate than tickrate!

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

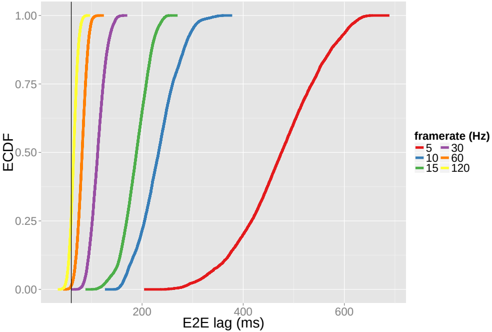
median of 1000 rounds for each bar; 40 ms base network RTT



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"

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
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In the future:

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

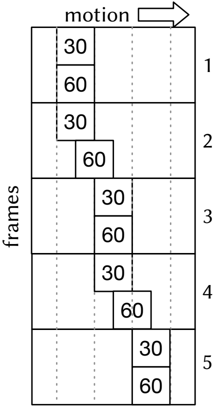
$\boxed{\text{Questions?}}$

`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


motion
frames
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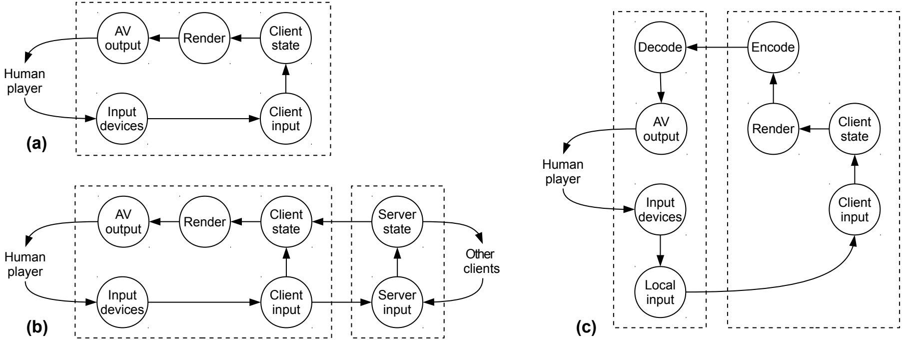
http://hugelol.com/lol/364250



(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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