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ESSEN

*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 (Competitively played at 120+)



scene from <https://www.youtube.com/watch?v=0215vVx1JhU>

same scene at 6fps



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  - Wrong choice of metrics to detect effects of lag (e.g. time-scale wise)
  - Focus just on network delay, not full E2E lag
  - Often short observation periods
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  - Many interlocked mechanics in play, we need to understand their effects!
  - Specifically: framerate and tickrate
- ⇒ Set up a small simulation to get some rough numbers

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Rate at which the game renders distinct images. Frametime is the duration a frame is displayed.

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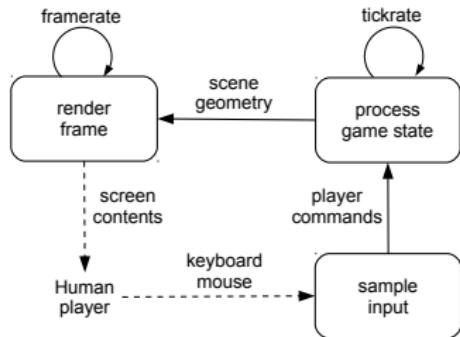
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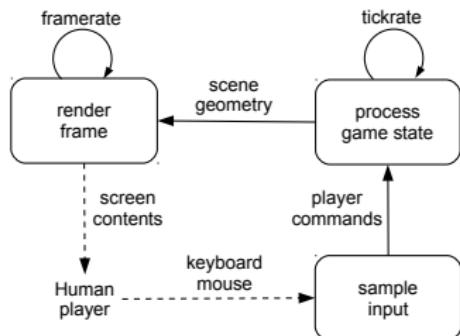


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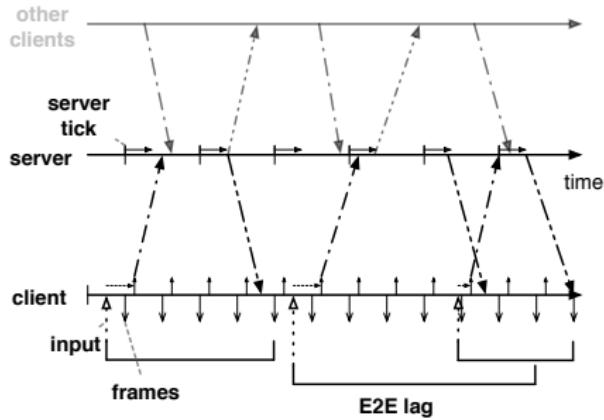


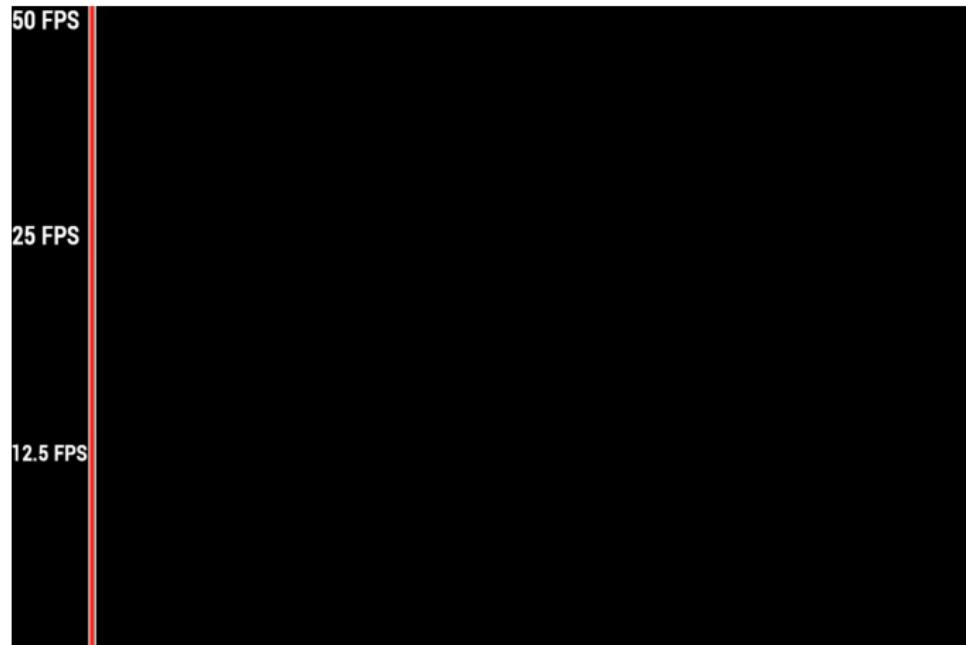
### Framerate constraints:

- Motion perception in video: Based on principle of apparent motion according to [Wer12], starting at a min. frame rate of 16 Hz
- Common game frame rates:  
30 Hz, 60 Hz, 120 Hz, 144 Hz

- 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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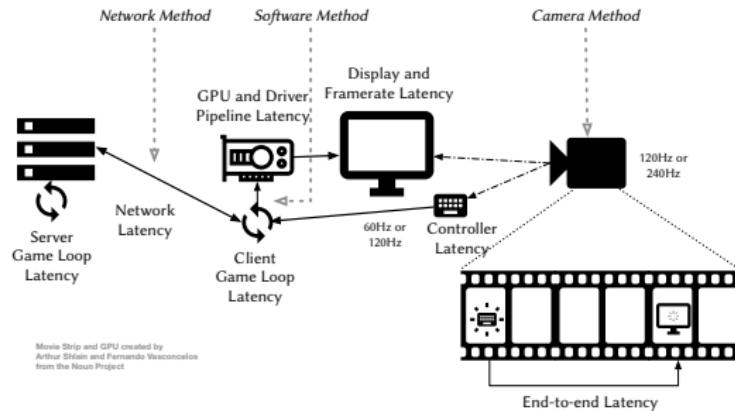




<http://blog.logicalincrements.com/2015/04/does-fps-matter-decide-for-yourself/>

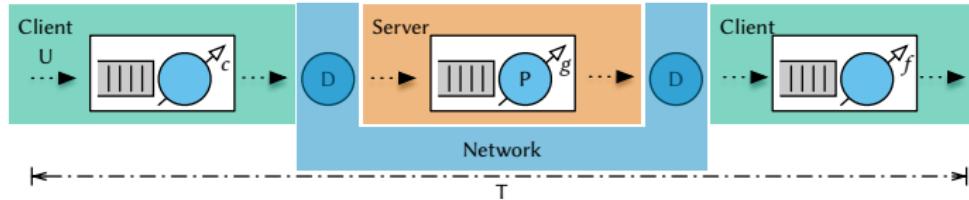
- Lag affects reaction and timings in gameplay ⇒ player performance
  - ⇒ Potentially largest **QoE** influencer
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- Instead of measurements: lag sources modeled in a queuing system
- **Goal:** investigate lag sources not typically attributed to lag
  - Especially: frame- and tickrate; but also: message rates, input and display devices, ...
- Frame- and tickrate modeled as independent, clocked processes

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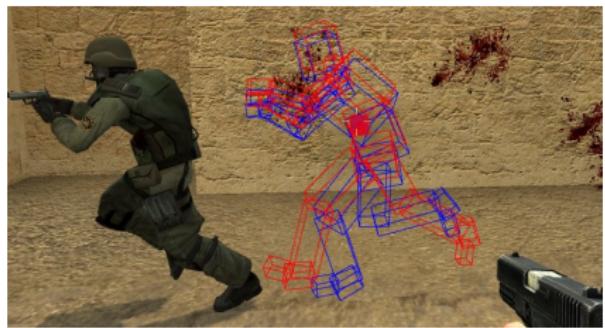


- Implemented as an R simulation<sup>1</sup>
- Evaluated for several scenarios and parameter combinations

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

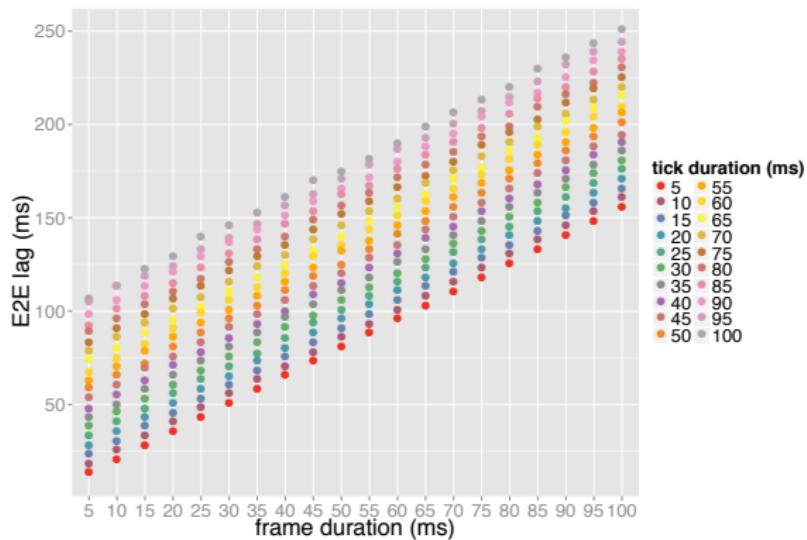
Examples of features that can reduce lag impact in games, but are not considered in the model and sim:

- 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



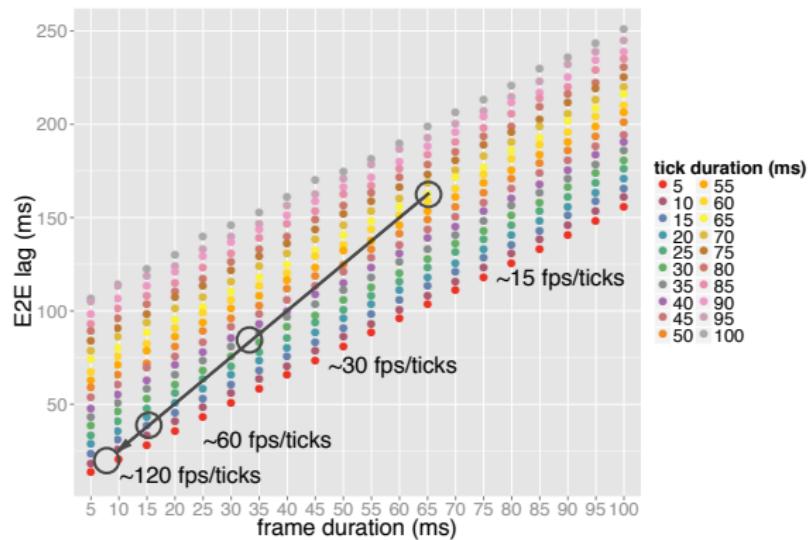
[developer.valvesoftware.com/wiki/Lag\\_compensation](http://developer.valvesoftware.com/wiki/Lag_compensation)

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



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

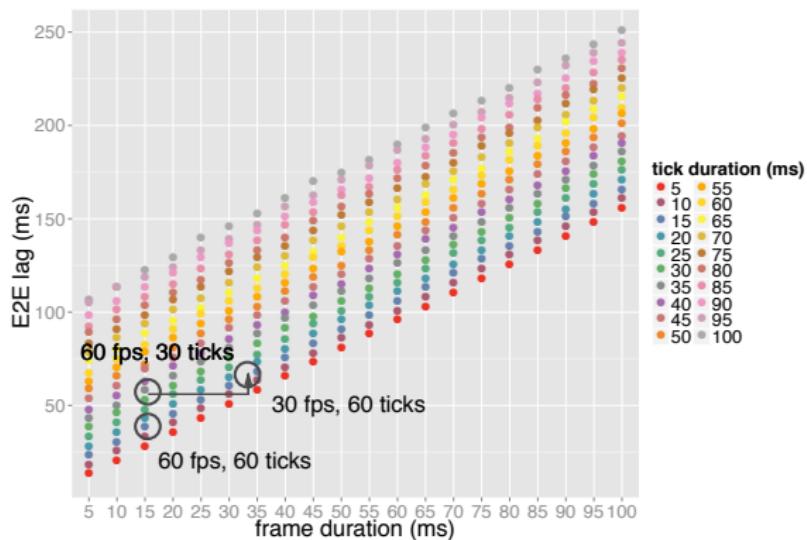
Locally running C/S-game, no network interactions involved, average of 1000 runs.



Linear decrease of E2E lag

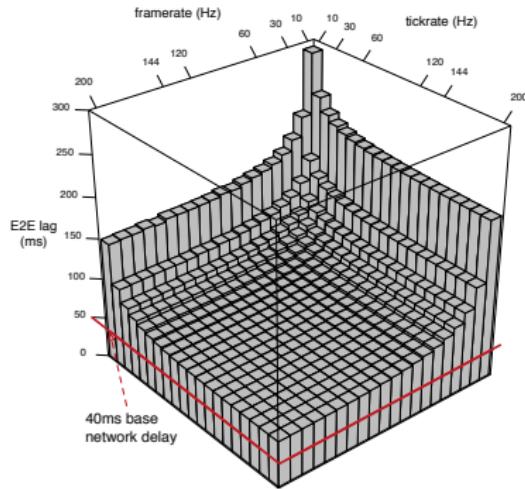
e.g.: 50 ms less when going from 30 to 60 fps and ticks.

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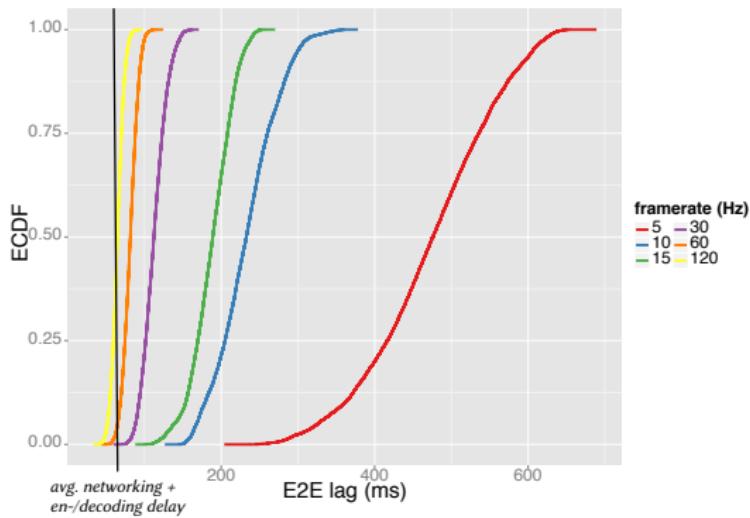
Bigger impact of framerate than tickrate!

Median lag of a networked game at 10 Hz to 200 Hz frame- and tickrates



**Network is not the main source of lag at low frame-/tickrates!**

Similar to networked C/S but with added video en-/decoding delay and frame transmission times.



Large E2E lag and wide spread of lag values

⇒ **Gameplay actions appear to be “stuttering”!**

Recap:

- Examining framerates and tickrates as a large QoE factor
- Simplified simulation of typical gaming scenarios
- Complex scenario due to interactivity and diversity of video games
- Larger influence of framerates than generally thought in academia

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In the future:

- More extensive simulation setup (more influence factors, variable framerates, triple buffering, ...)
- Focus on frametimes and resulting stuttering
- Cross-check with real world E2E lag measurements
- Derive guidelines for future gaming user studies

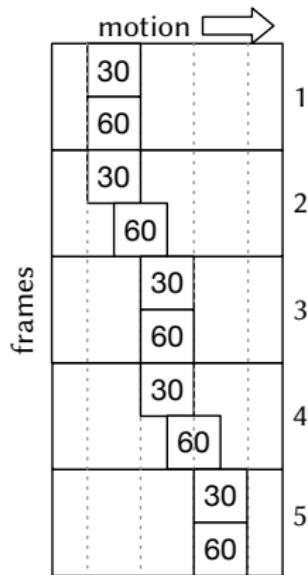
# Questions?

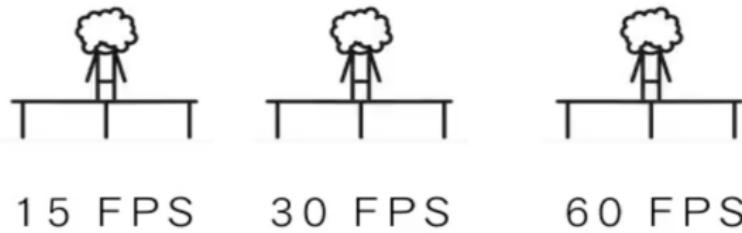
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Contact: [florian.metzger@uni-due.de](mailto:florian.metzger@uni-due.de)

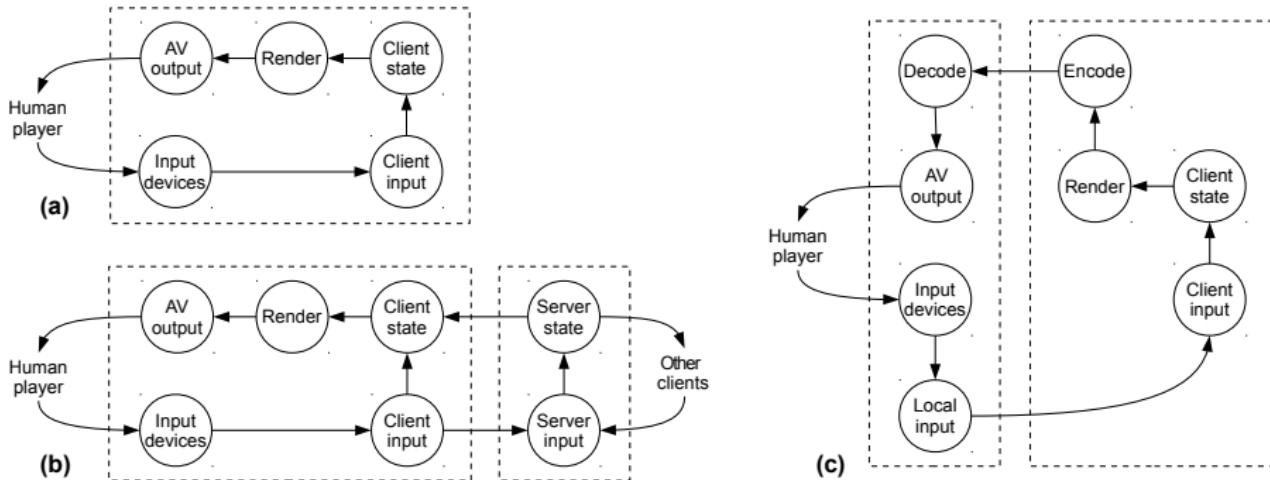
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<http://hugelol.com/lol/364250>



(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 not verified and may be unreliable



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