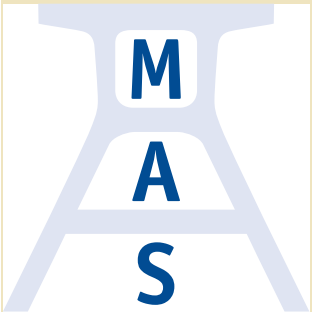

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A Comprehensive End-to-End Lag Model for Online and Cloud Video Gaming

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

Modeling of Adaptive Systems

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

Motivation

QoS and QoE of TCP Streaming in Mobile Networks?

What is Lag?

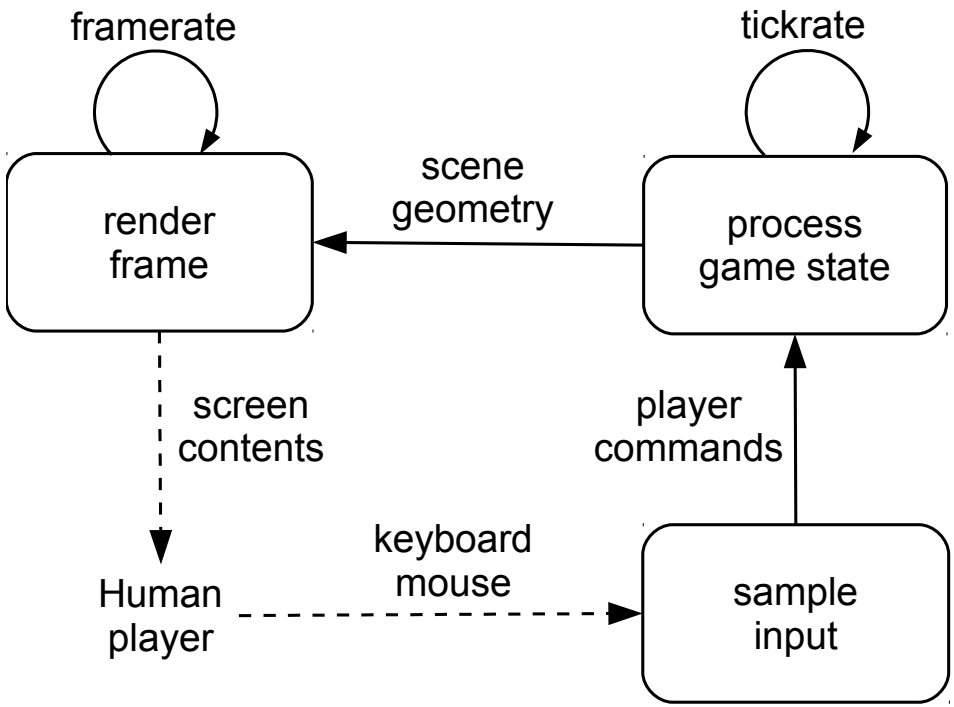
Definition from Halo: Reach Programming Gameplay networking

- Perceived delay or inconsistency
- Caused by various latency sources
- Caused by bandwidth limitation
- Caused by packet loss
- Sometimes caused by game mechanics

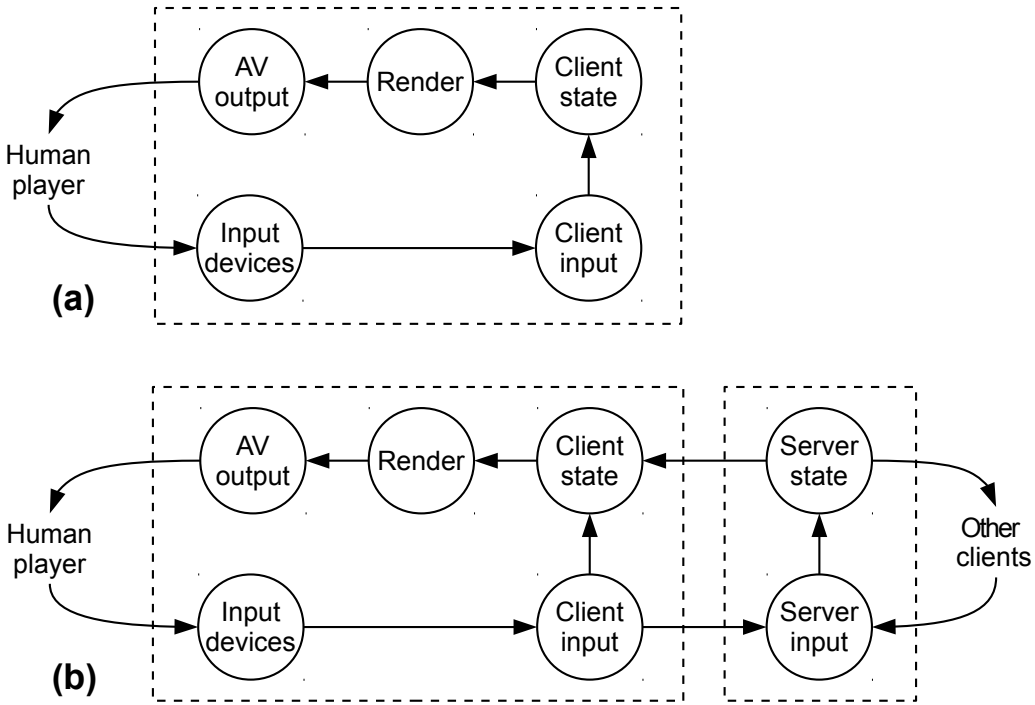
Model Limitations: Lag-Concealing Features

These have to be present in actual authoritative client-server video games, but are not yet considered in the model

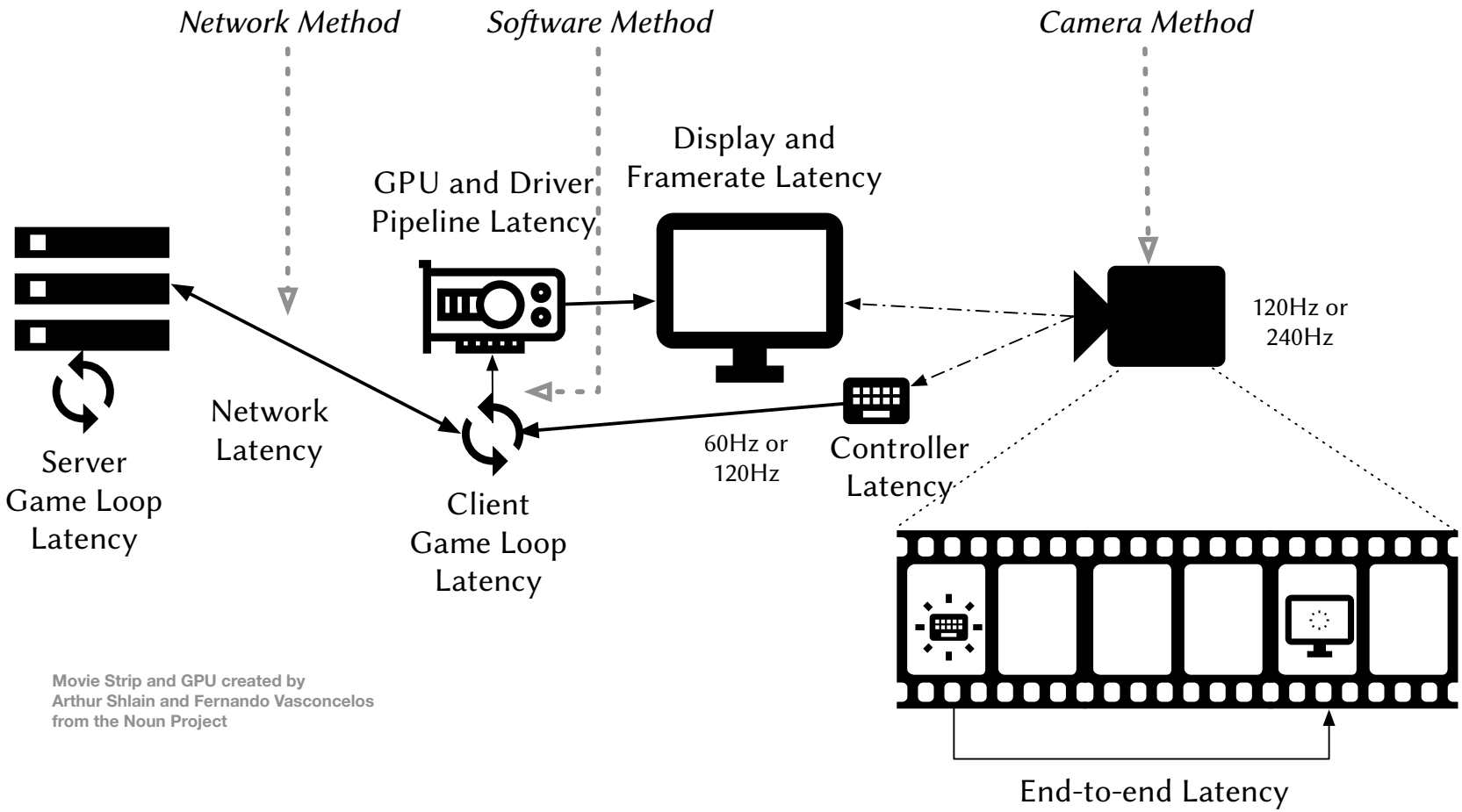
- Immediate visualization through client-side prediction of object actions (e.g. player movement) (without waiting for authoritative answer)
- Visualization interpolation between snapshots // extrapolation from last two server game state snapshots
- Lag compensation by doing hit detection on object positions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



Basic model of a continuous main video game loop.



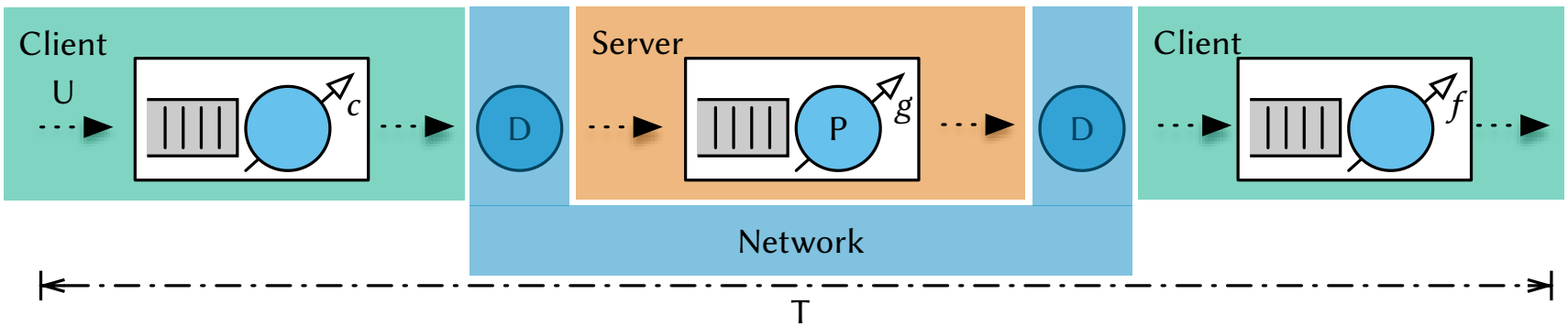
Interactions between components in different video game models. *(a)* Single-player, *(b)* online, *(c)* cloud game.



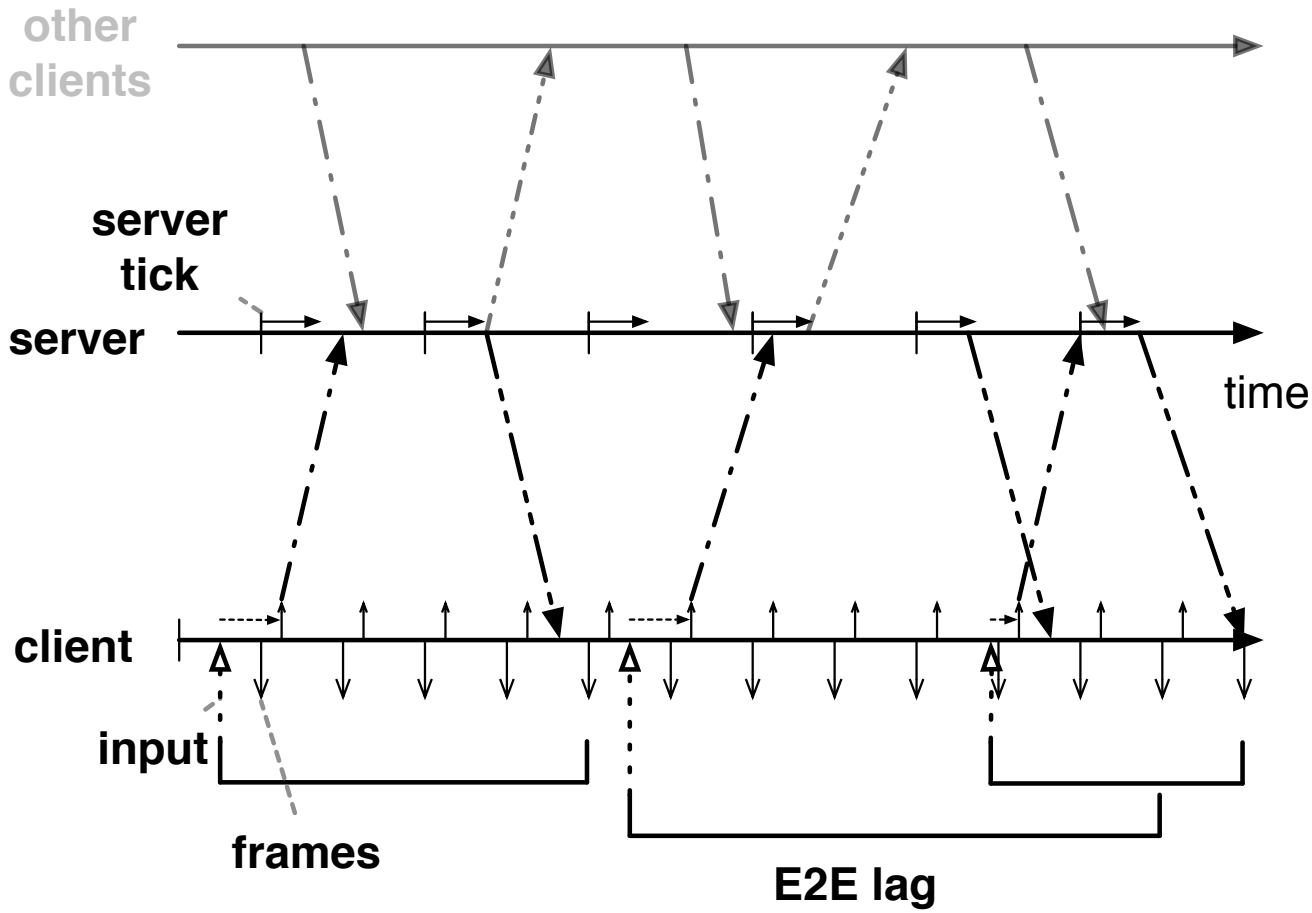
Location of three measurement approaches to capture end-to-end lag in an online video game.

Tickrates in competitive and popular video games that are either known, speculated upon, or derived by counting update and command messages. Data was collected from various sources and should be taken as-is.

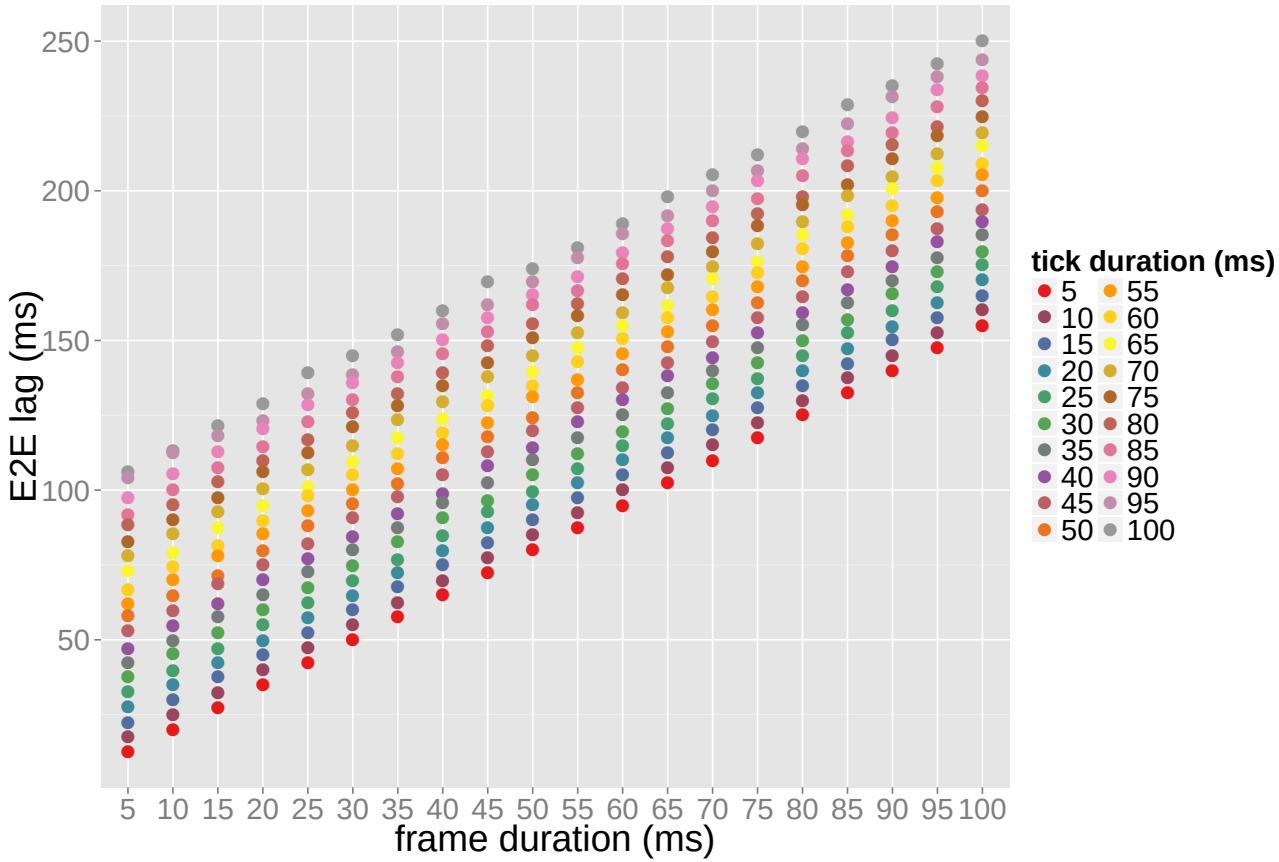
Video Game	**Tickrate**
CS: GO	Configurable 64 Hz/128 Hz
Battlefield 4	30 Hz; 10 Hz for state outside of close proximity to player; 60 Hz/120 Hz on test servers.
Minecraft	max. 20 Hz
League of Legends	30 Hz (estimated)
Dota 2	30 Hz
StarCraft II	supposedly either 16 Hz or 32 Hz
Eve Online	1 Hz
Project Cars	600 Hz (Physics), 250 Hz (Input)



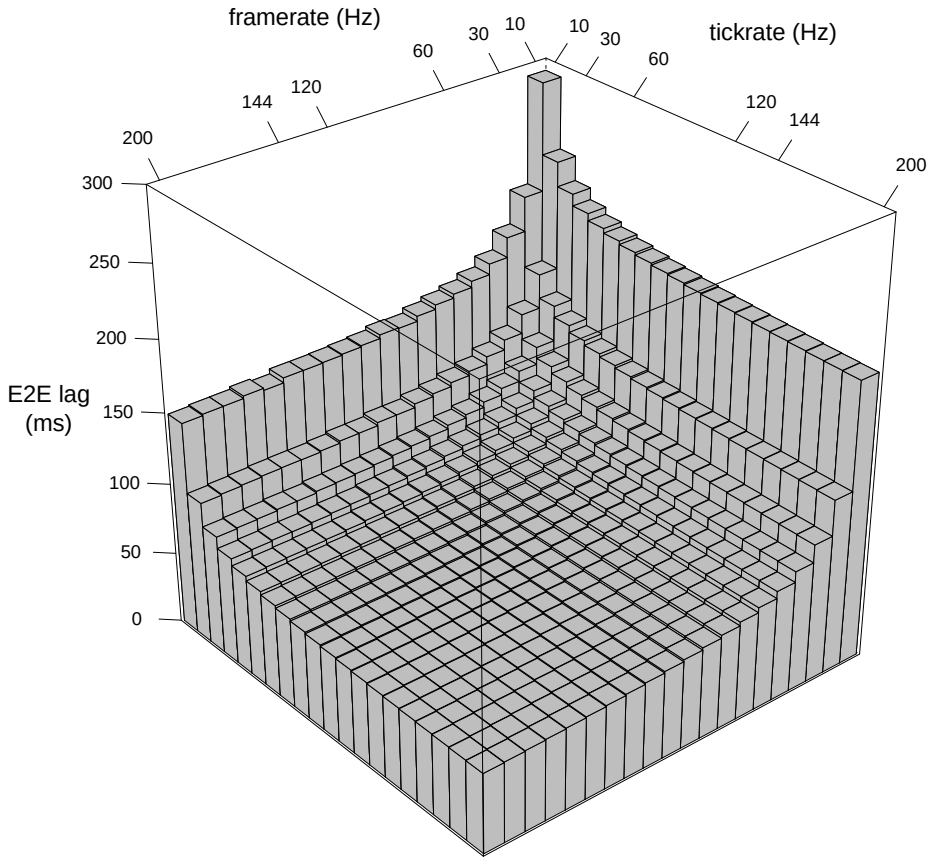
Queuing lag model in an online video game case.



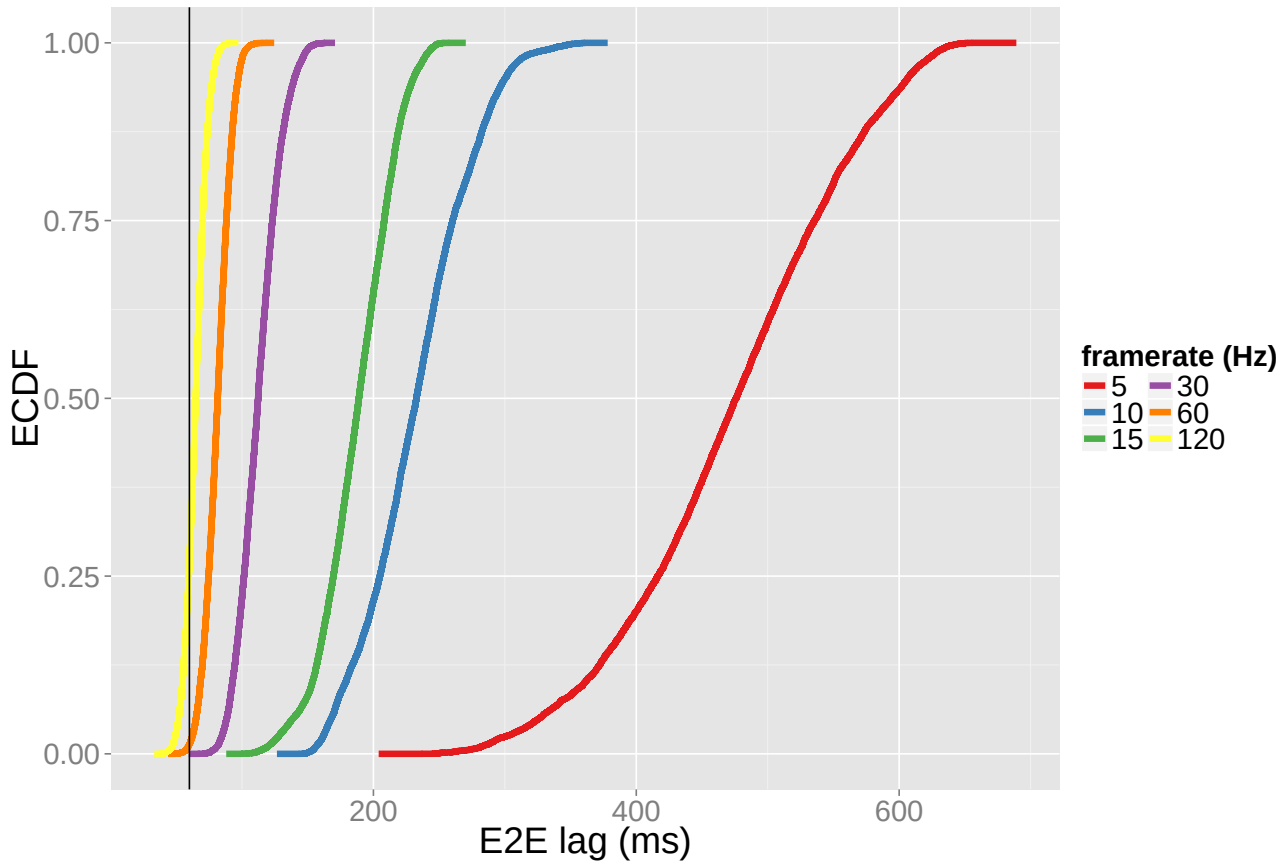
Exemplary flow of events in an online client-server game, and resulting end-to-end lag with the notation of Tab. ??



Median End-to-End (E2E) lag under various frame and tick durations for a locally-running game (§??). Lower lag values are achieved at lower frame and tick durations; the frame duration has a larger influence on the E2E lag.

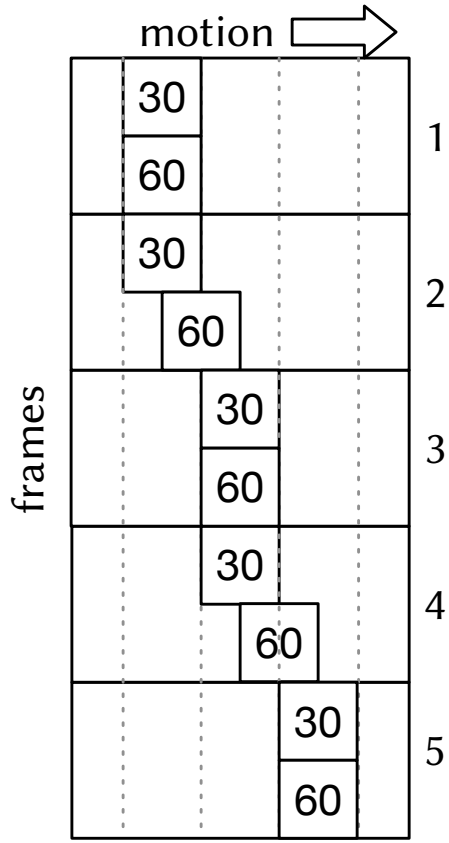


Influence of client framerate and server tickrate on the median E2E lag in the online game scenario (§??). Only for high rates f, g, the lag is dominated by the network round-trip and server processing time, $T \approx 2\mu_D + \mu_P = 43\,\text{ms}$.



Influence of the rendering and streaming framerate on the E2E lag in the cloud scenario (§??).

The vertical reference line denotes the average server processing time, network round-trip and codec delay $\mu_P + 2\mu_D + e + d = 68\,\text{ms}$.


motion
frames
30
60
30
60
30
60
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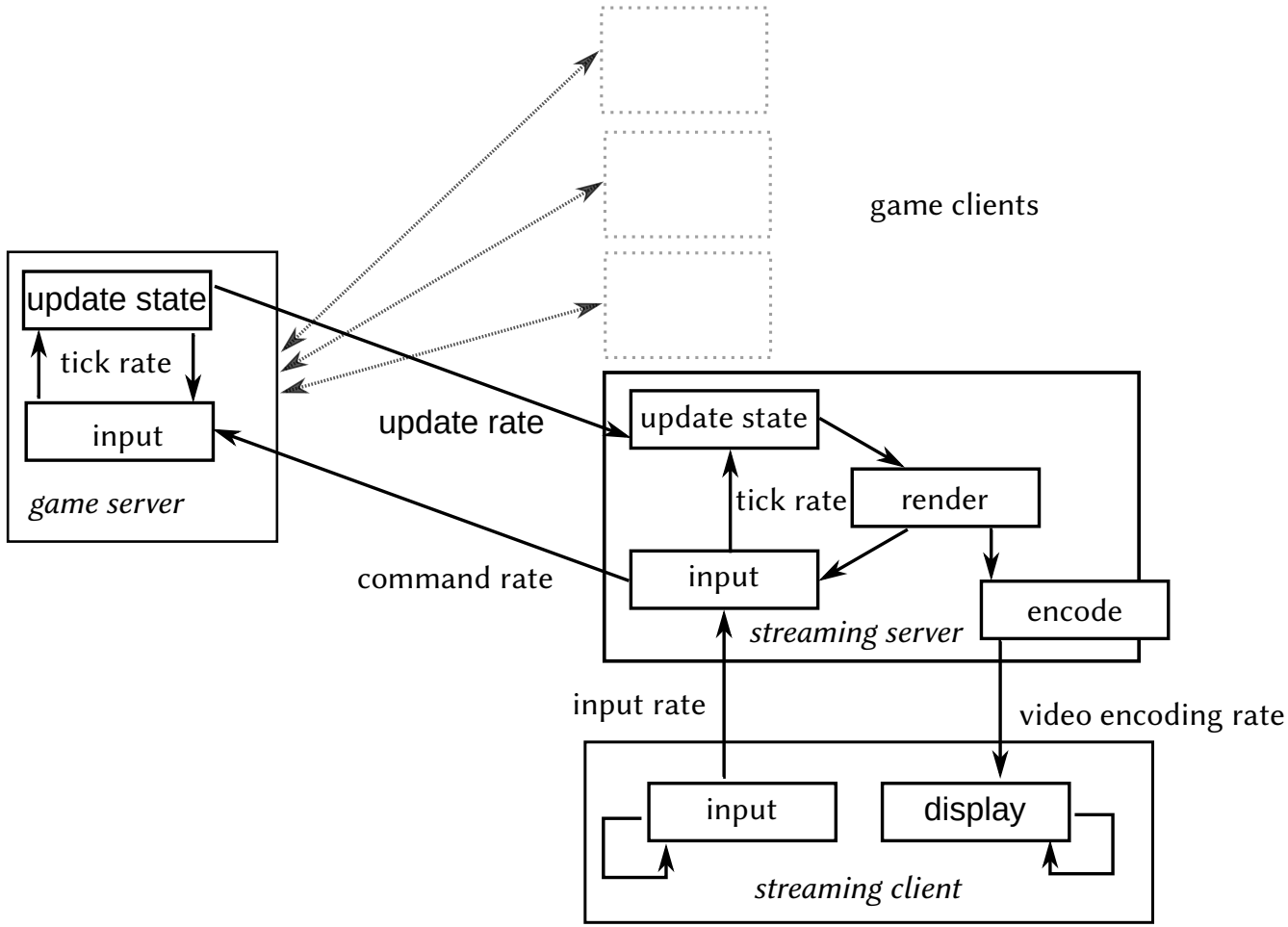
60
30
60
1
2
3
4
5


game clients
update state
tick rate
input
game server
update rate
command rate
update state
tick rate
render
input
encode
streaming server
input rate
video encoding rate
input
display
streaming client