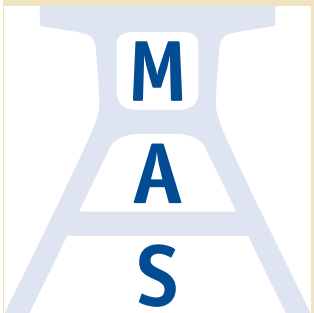

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A Comprehensive End-to-End Lag Model for Online and Cloud Video Gaming

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

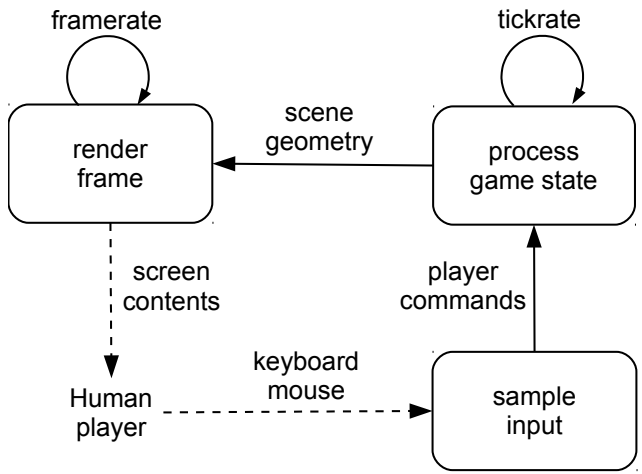
- Increasing research interest for (networked) video game QoS and QoE
- Past approaches treated video games similar to video streaming
- Studies focused only on network delay, not E2E lag
- Many interlocked mechanics in play
- Need for a better understanding of these mechanics
- Looking only at authoritative client/server games here, not peer-to-peer

Issues of Past Studies

- Insufficient framerates (actual examples: 3 Hz, 7 Hz, 15 Hz)
- Wrong choice of metrics (e.g. time-scale wise)
- Observation periods too short
- No understanding of core gameplay mechanics
- Cannot generalize results from individual games to a whole “genre”

Frame- and Tickrates

- Framerate and tickrate are governing factors in input latency
- Low framerates are a source of lag
- Principle of apparent motion: objects are perceived to be in motion at a min. refresh rate of 16 Hz
- Common game frame rates: 30 Hz (considered to be the absolute minimum), 60 Hz, 120 Hz, 144 Hz

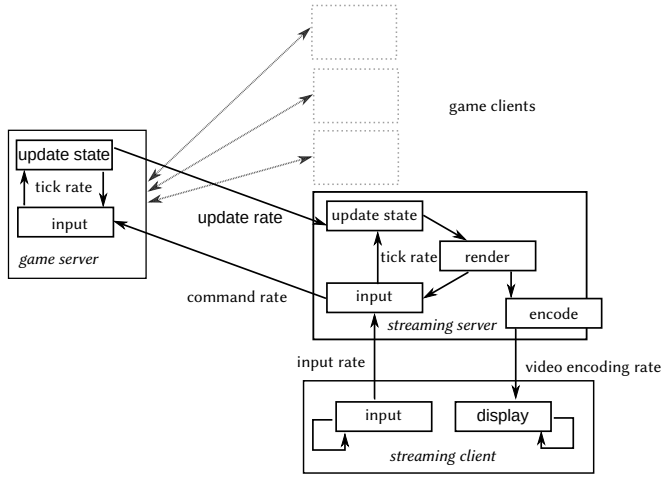


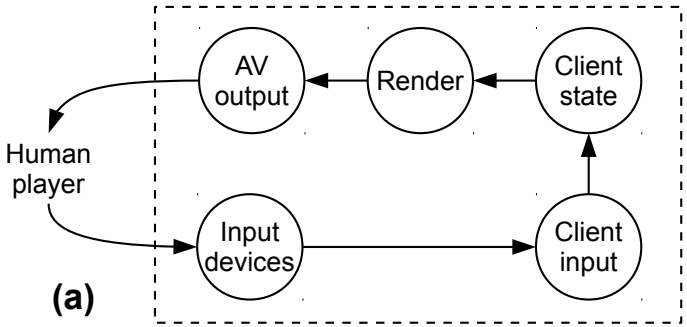
Basic model of a continuous main video game loop.

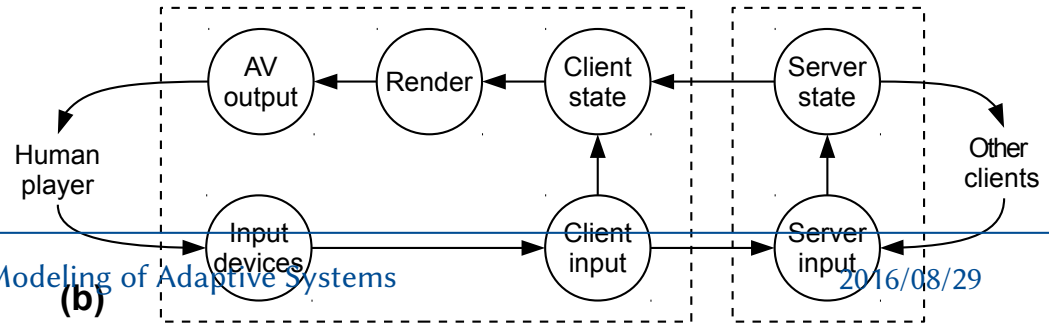
Information Deficit through Low Framerate

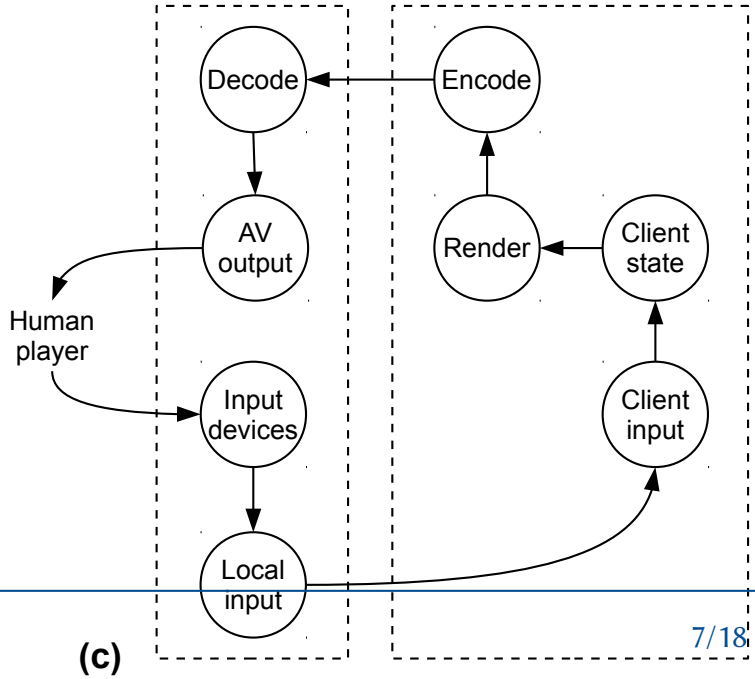
http://blog.logicalincrements.com/2015/04/does-fps-matter-decide-for-yourself/

Simplified Video Game Main Loops









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

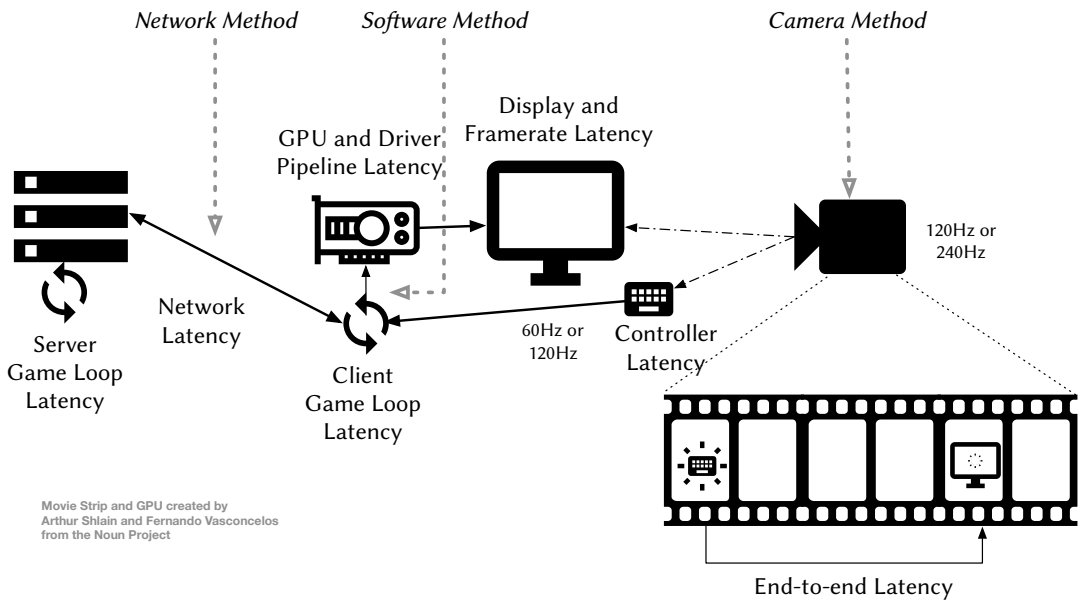
What is Lag?

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

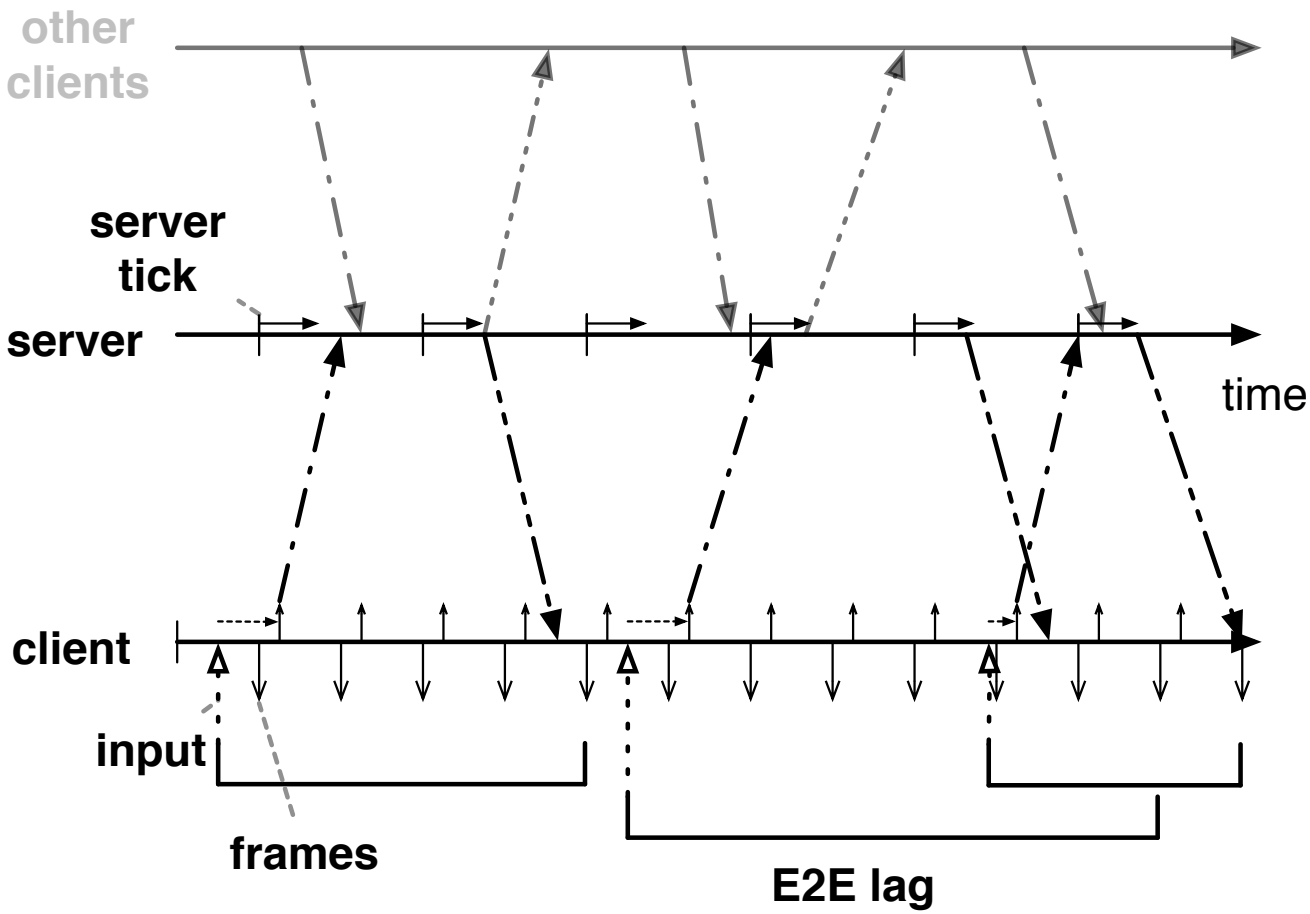
Attributes and Measures of Lag

- Lag affects gameplay
- 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



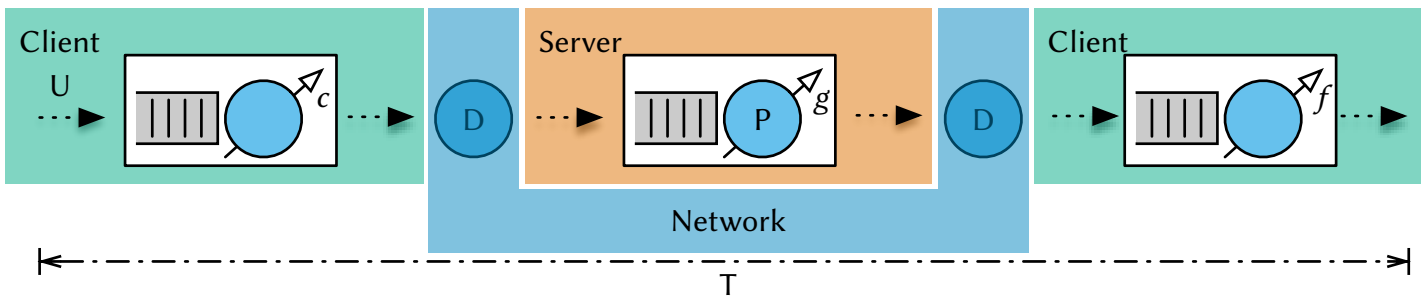
Location of three measurement approaches to capture end-to-end lag in an online video game.

E2E Lag Example



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



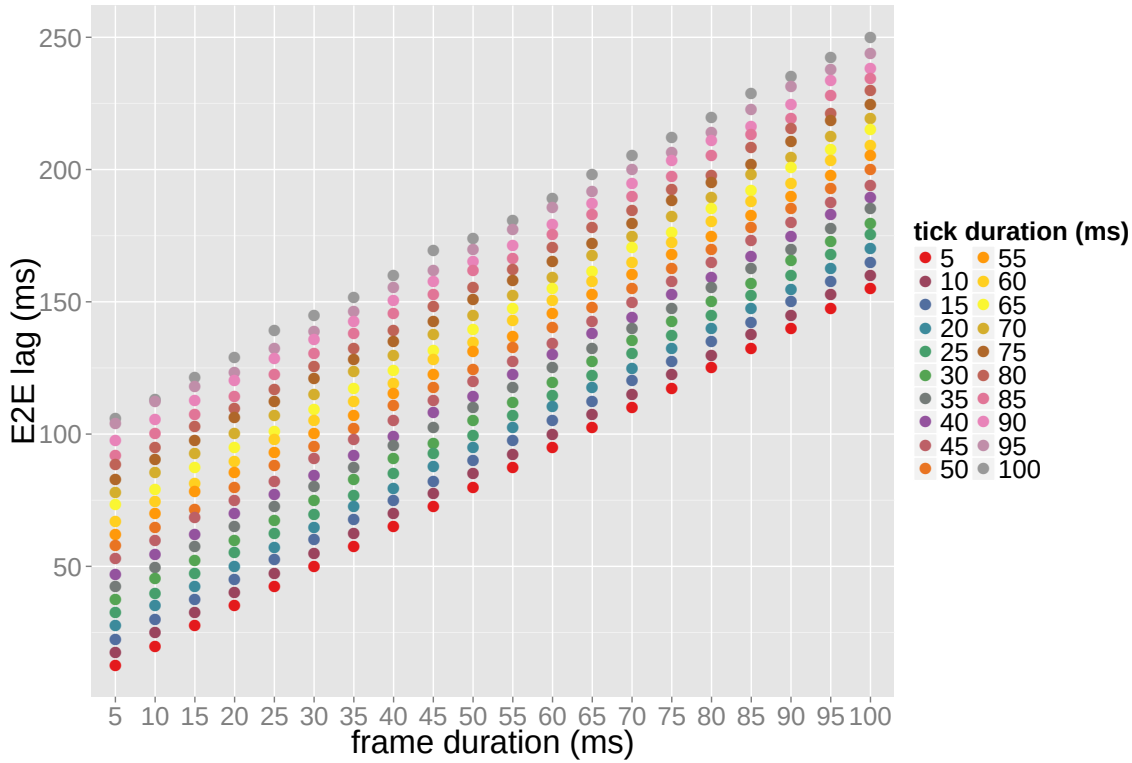
- Implemented as R simulation
- Evaluated for several scenarios and parameter combinations

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

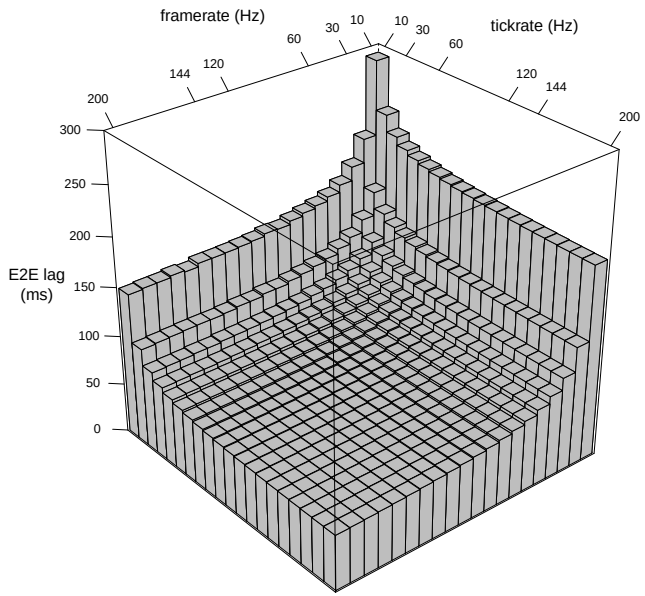
- Immediate visualization through client-side prediction of object actions (e.g. player movement) (without waiting for authoritative answer)
- Visualization interpolation between snapshots // extrapolation from last two server game state snapshots
- Lag compensation by doing hit detection on object positions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

Results: Local Game



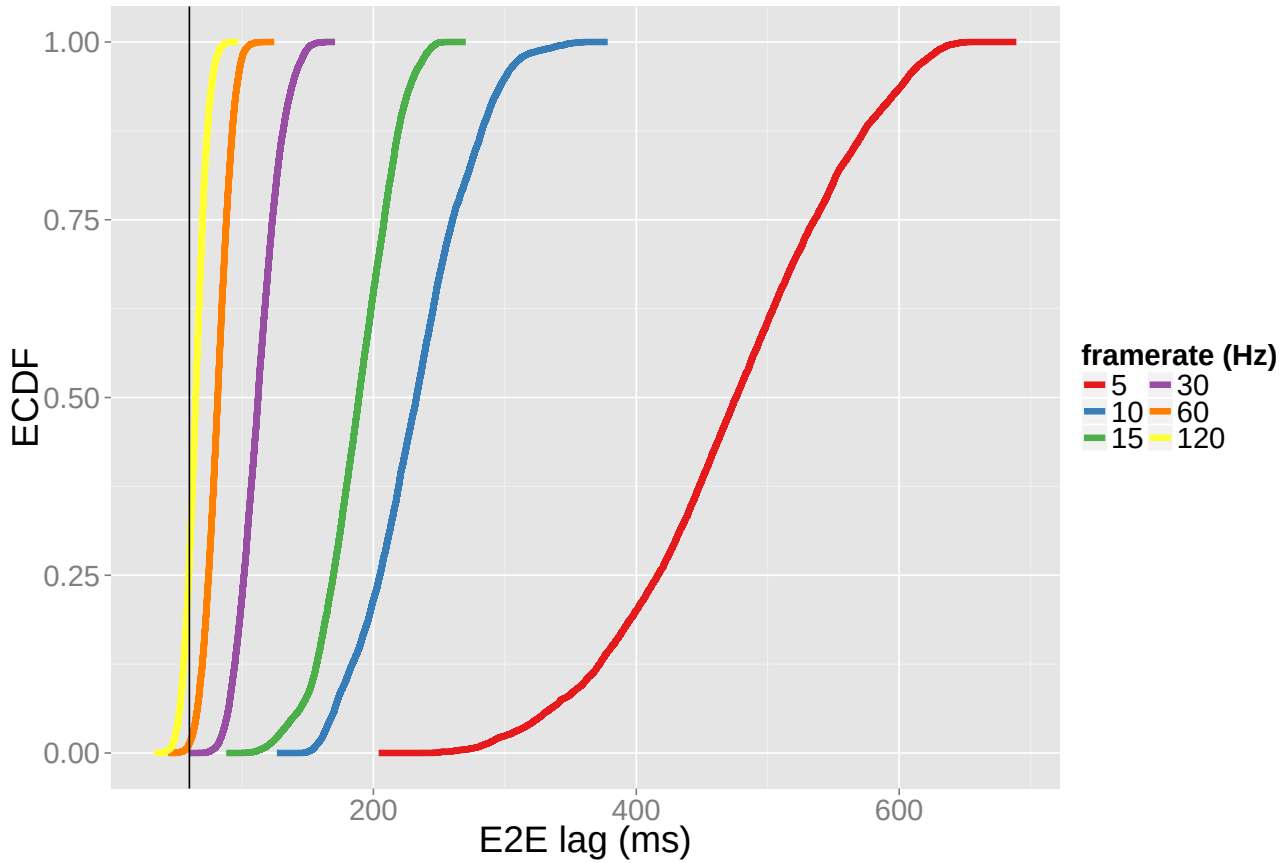
Median End-to-End (E2E) lag under various frame and tick durations for a locally-running game (§??). Lower lag values are achieved at lower frame and tick durations; the frame duration has a larger influence on the E2E lag.

Results: Networked Game



- Networked game at 10 Hz to 200 Hz frame- and tickrates; median of 1000 rounds for each bar
- 40 ms base network RTT
- Large influence of frame-/tickrate on E2E lag
- Negligible network influence at low frame-/tickrates

Results: Cloud Game



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 $\mu_P + 2\mu_D + e + d = 68\,\text{ms}$.

Conclusions

- Expected influence guidelines for future user studies

Thanks!

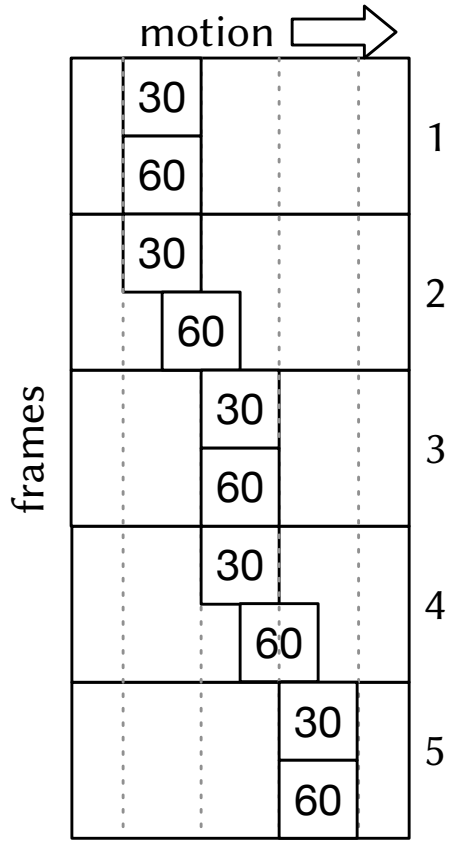
Questions!

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