Survey of video game streaming solutions

Aleksei Ivanov

Outline

- Introduction
- Previous works
- Evolution timeline
- State of the art
- Experiments
- Conclusion

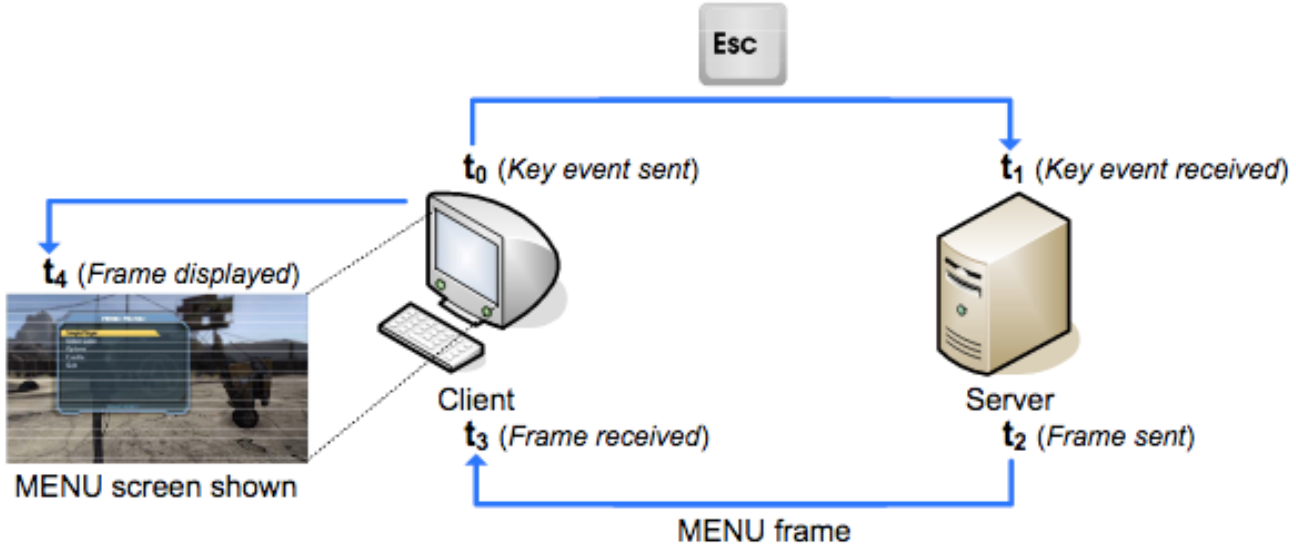
What is cloud gaming?

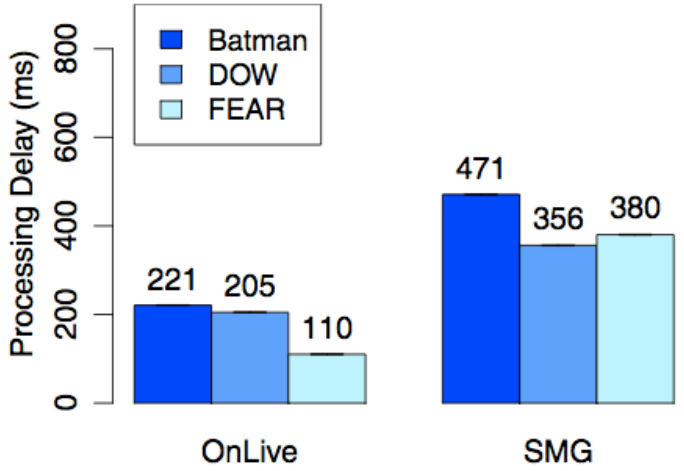
What is cloud gaming?

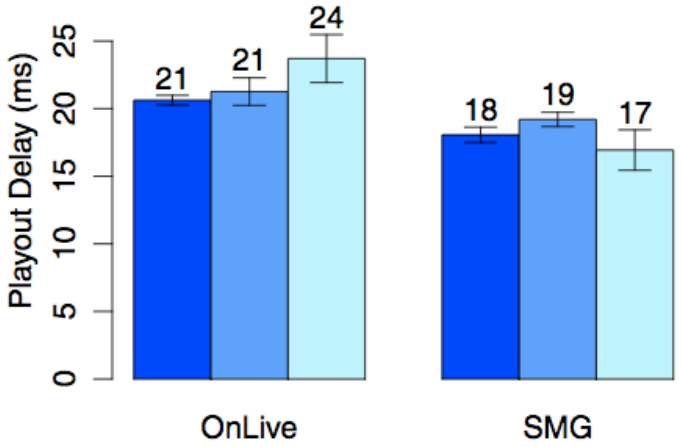
- **Thin client** approach
  - Laptops, smartphones, game consoles
  - Video & **control** streaming
- Usually **hardware** is provided
  - Easy to use – no setup required
- **Subscription** based (live-service model)
  - Games *might be* included (i.e. Stadia)

Previous works

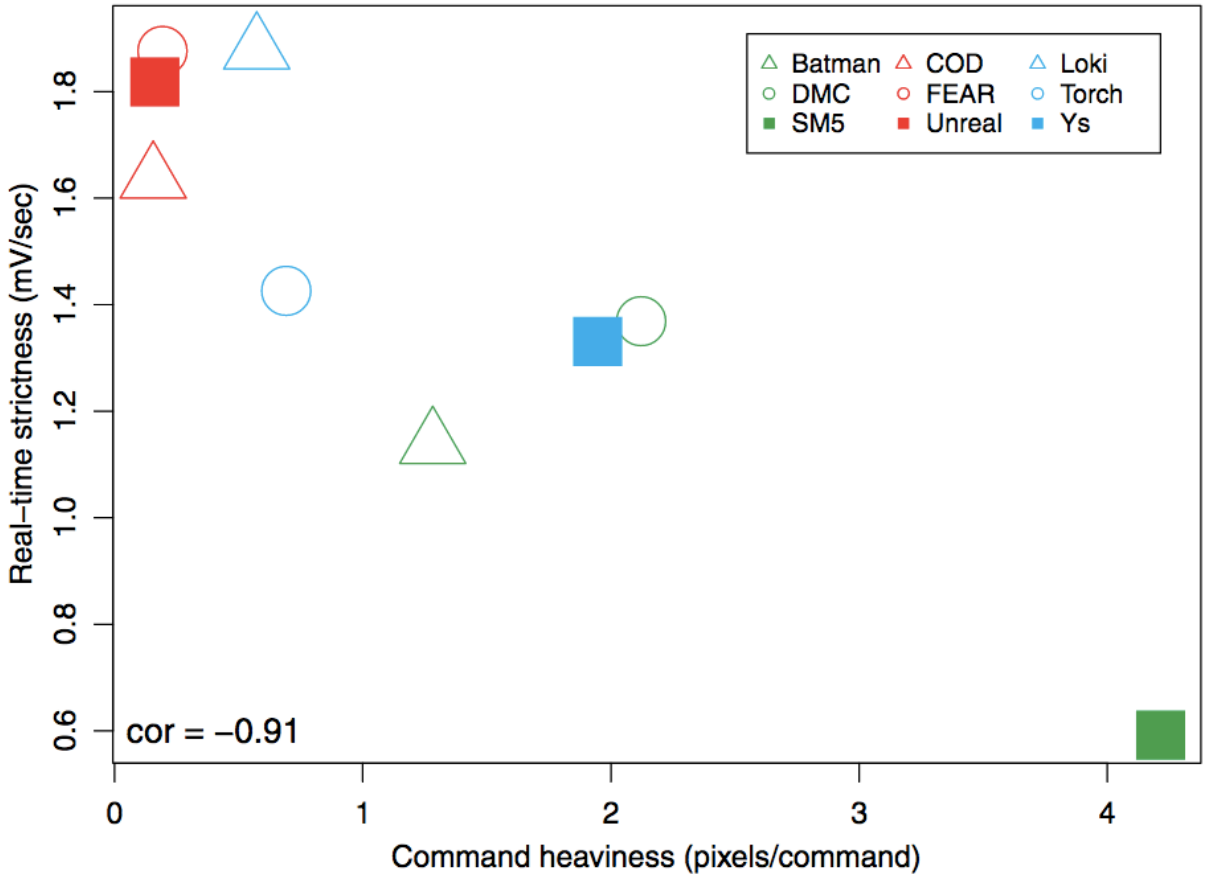
Measuring the latency of cloud gaming systems [Che11]







Are all games equally cloud-gaming-friendly? [Lee12]



Game genre, screen fidelity and reaction time – all affect cloud gaming experience

A Classification of Video Games based on Game Characteristics linked to Video Coding Complexity [Zad18]

TABLE II: Quantification of game characteristics.

Name	Class	DoF	MT	CP	ACM	TD	ON	CD	SA	CR
CSGO_P1	3	6	3	3	3	4	3	2	0	0
CSGO_P2	2	6	3	3	2	4	3	2	0	0
Diablo_P1	1	3	2	1	2	3	3	2	1	0
Diablo_P2	1	3	2	1	1	3	3	2	1	0
Dota2_P1	1	3	2	0	0	4	3	2	2	1
Dota2_P2	1	3	2	0	0	4	3	2	2	1
Euro_P1	2	2	2	3	3	4	3	3	4	0
Euro_P2	2	2	2	1	3	4	3	3	2	0
FIFA17_P1	2	2	2	1	3	4	5	3	1	0
FIFA17_P2	2	2	2	1	3	4	5	3	1	0
H1Z1_P1	3	6	3	3	3	4	4	2	0	0
H1Z1_P2	2	6	3	3	2	4	4	2	0	0
HoTS_P1	2	3	2	1	2	3	3	2	2	0
HoTS_P2	2	3	2	1	2	3	3	2	2	0
HS_P1	1	0	0	0	0	3	2	2	4	2
HS_P2	1	0	0	0	0	3	3	2	4	2
LoL_P1	1	3	2	1	1	3	3	2	2	1
LoL_P2	2	3	2	1	2	3	3	2	2	1
OW_P1	3	6	3	3	3	4	3	2	0	1
OW_P2	3	6	3	3	3	4	3	2	0	1
PC-P1	2	2	2	2	3	5	4	3	2	0
PC-P2	2	2	2	2	3	5	4	3	4	0
PUB_P1	2	6	3	2	2	4	4	2	1	0
PUB_P2	3	6	3	3	3	4	3	2	1	0
Rayman_P1	2	2	1	2	3	3	3	2	0	0
Rayman_P2	2	2	1	2	3	3	3	2	0	0
SC_P1	1	3	2	2	1	3	3	2	3	0
SC_P2	1	3	2	2	1	3	3	2	3	0
Somi_P1	1	1	1	1	3	2	3	1	4	2
Somi_P2	1	1	1	1	3	2	3	1	4	2

Affects bandwidth usage for service provider *in theory*

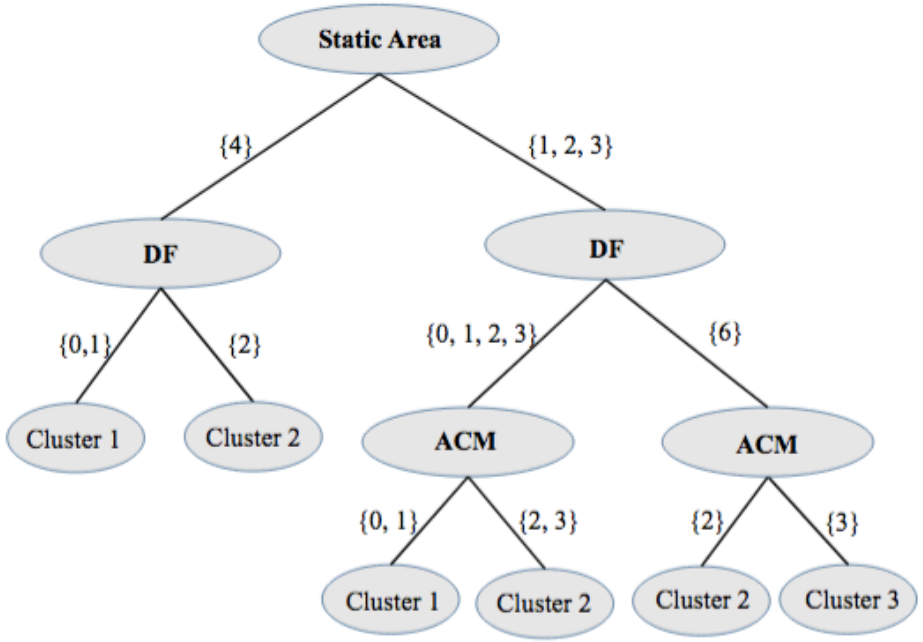


Fig. 2: Decision tree based on different coding complexity groups and game characteristics (DF refers to degree of freedom, ACM refers to amount of camera movement).

Adaptation Under Different Network Conditions: the Case of NVIDIA GeForce NOW [Suz16]

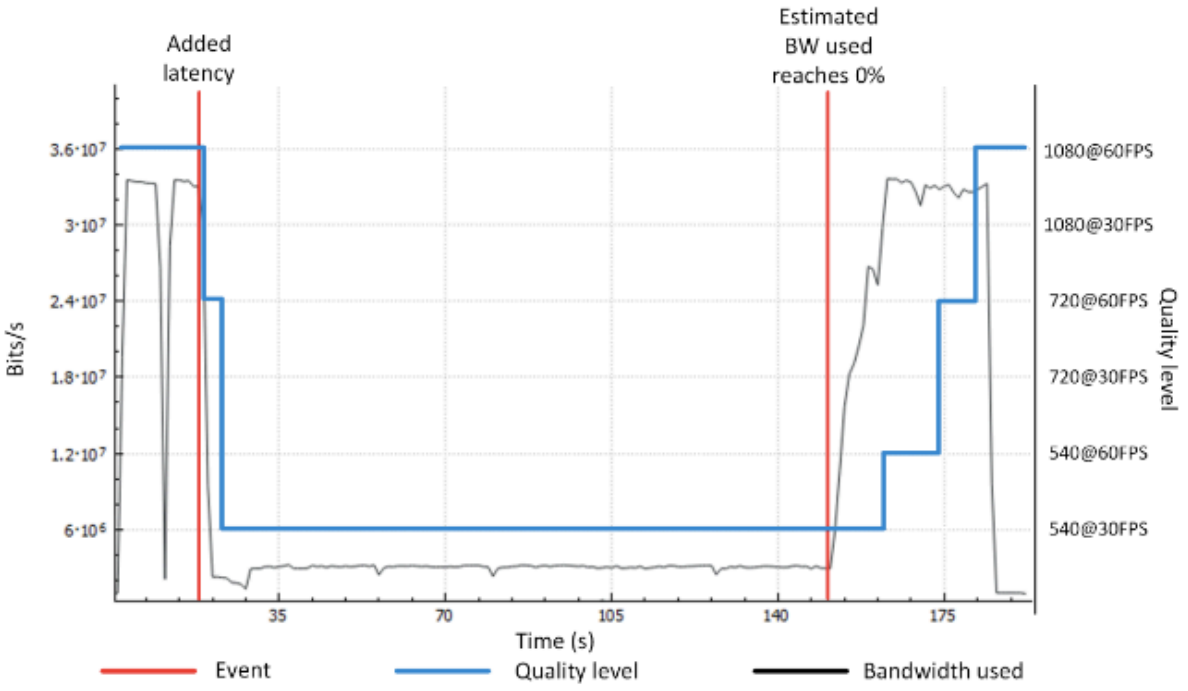


Fig. 3: Adaptation with active gameplay in Dirt 3

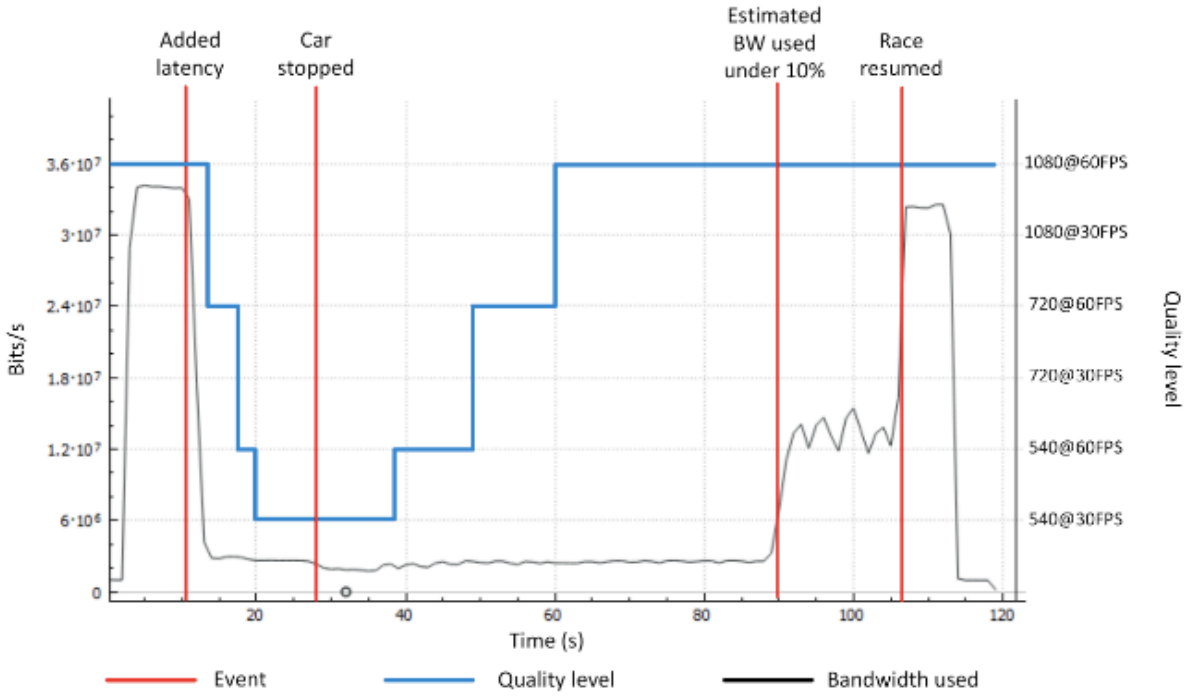
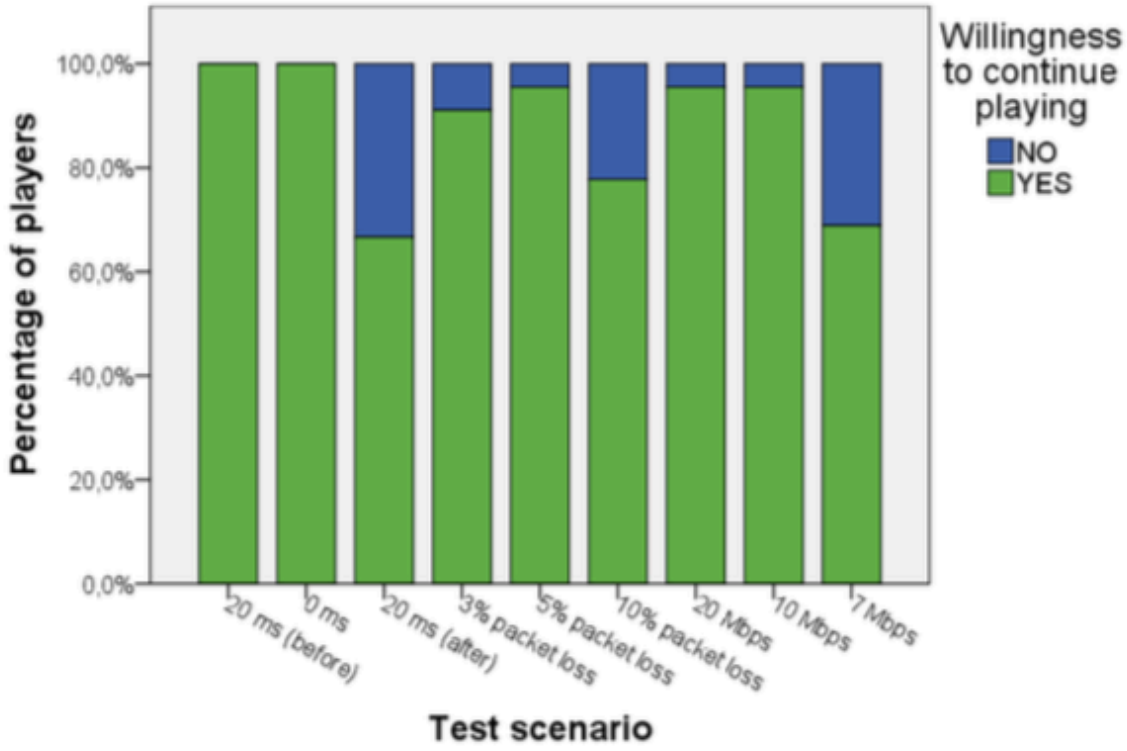
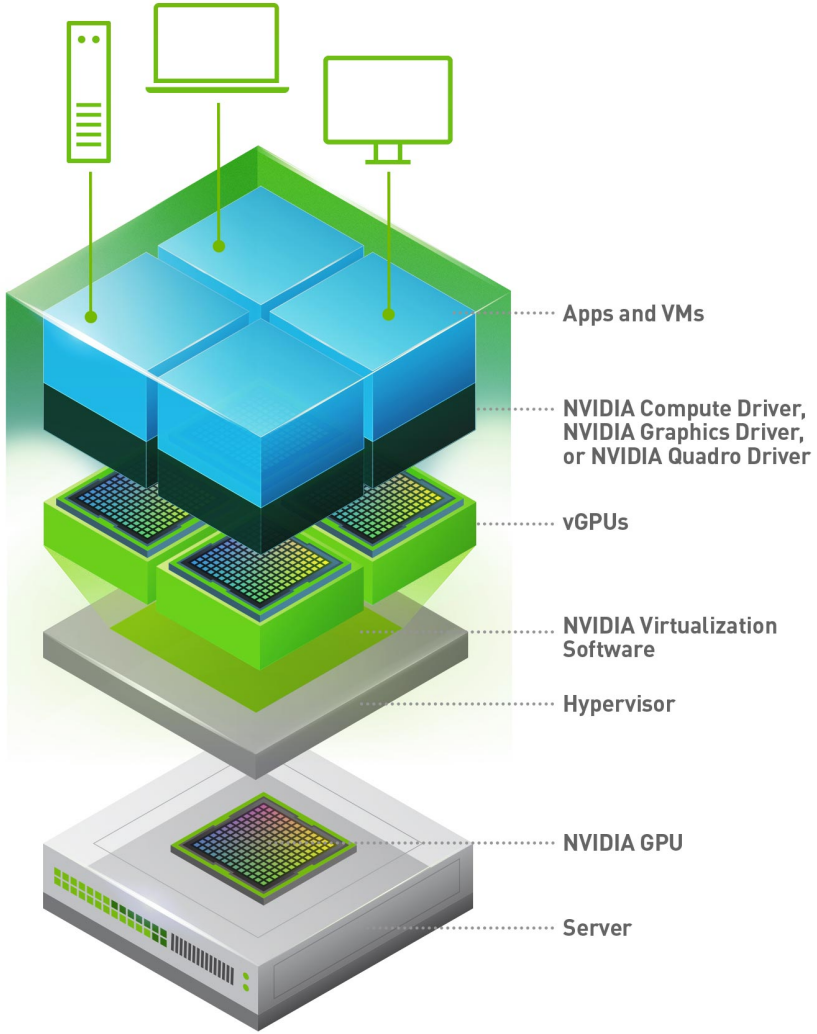


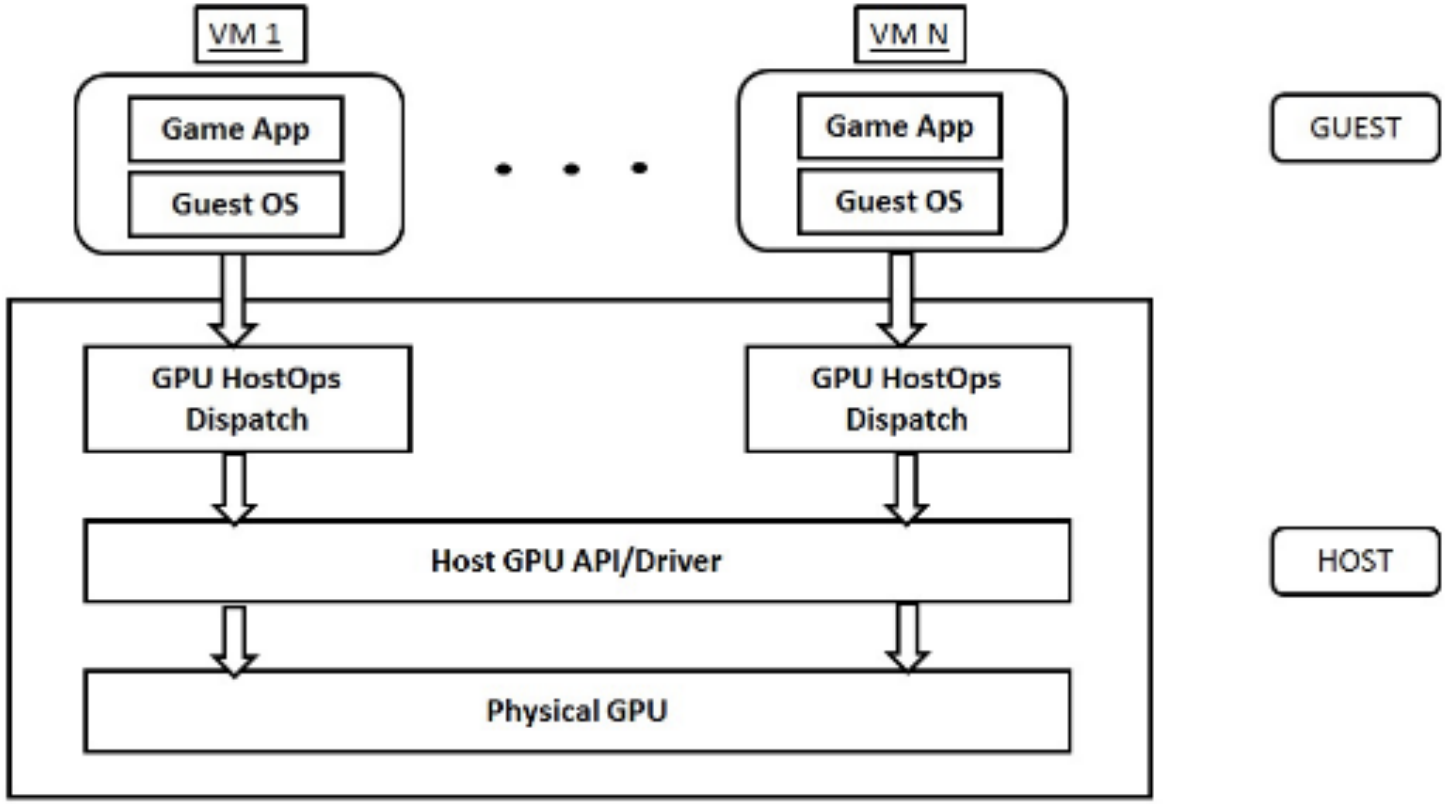
Fig. 4: Adaptation with passive gameplay in Dirt 3

Adaptation Under Different Network Conditions: the Case of NVIDIA GeForce NOW [Suz16]

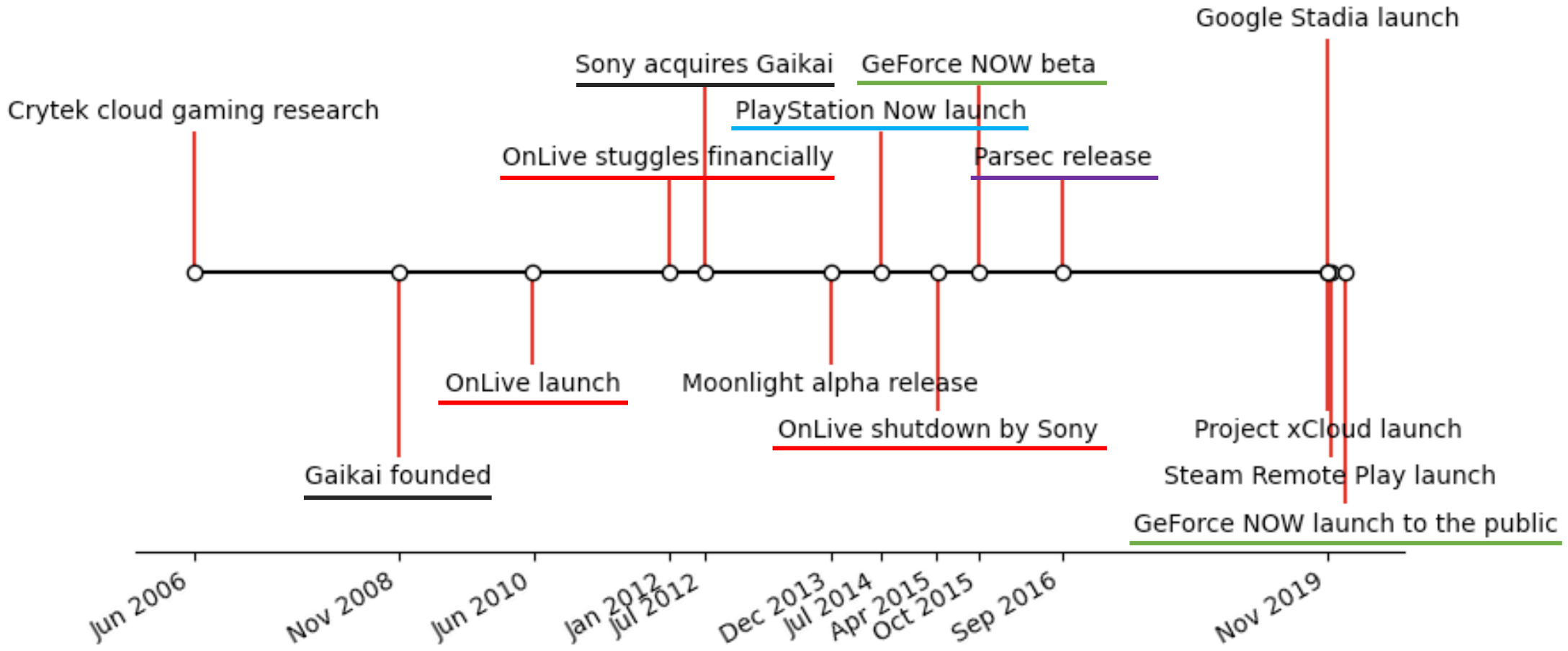


Adaptive GPU resource scheduling [Yad17] and GPU virtualization technologies [NVI20b]





Cloud gaming technologies timeline



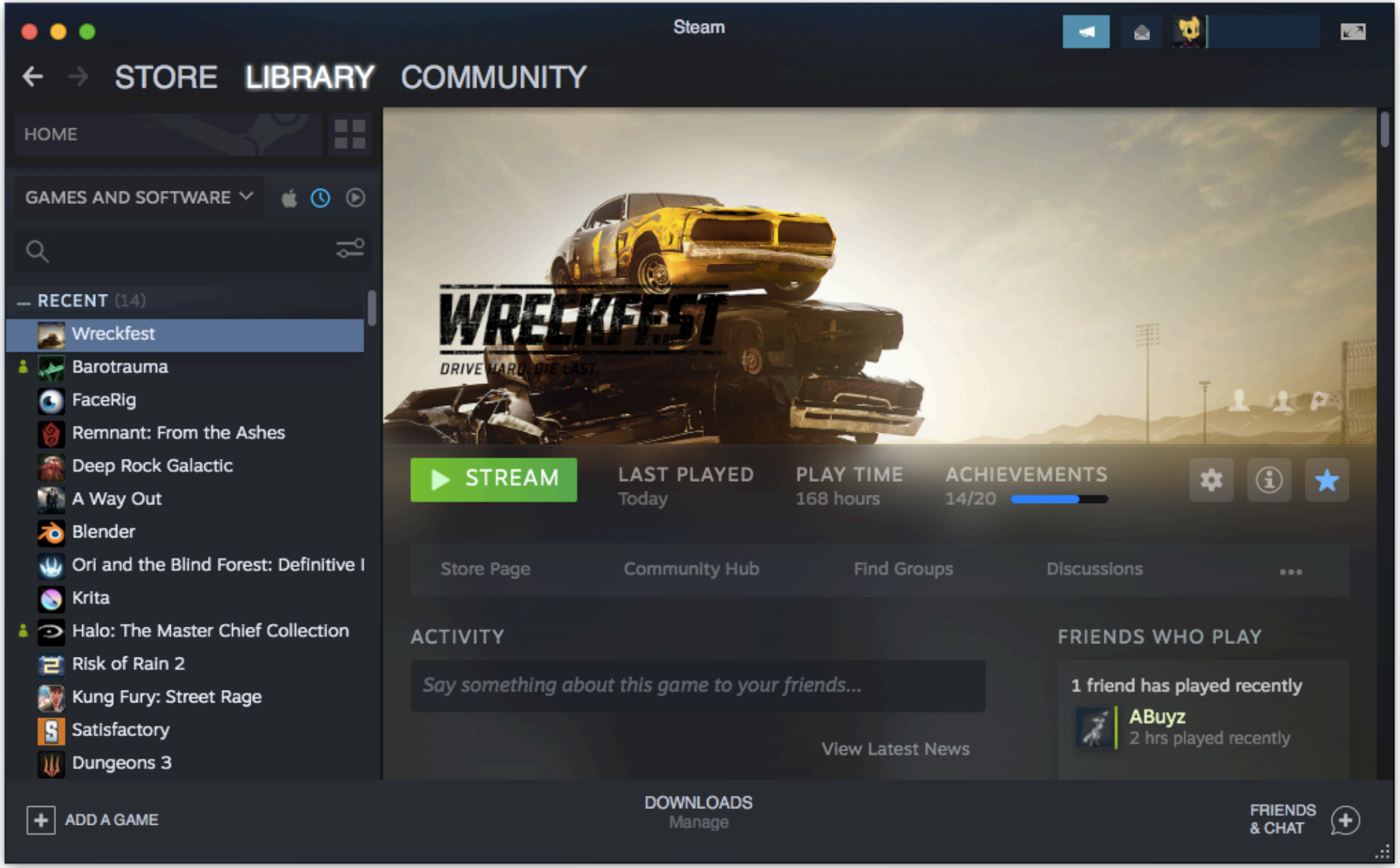
State of the art

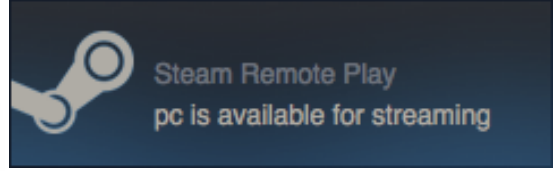
- Service description
- Business model
- Features

Steam Remote Play

[Val20]

- Steam is the largest video game store on PC
- **Free** (registration required)
- **Cross-platform** (Mac, Windows, Linux)
- Available on **mobile** (through the Steam Link app)
- Only purchased games from the library (more than **30,000** games)
  no ability to play games not in the store
- **No hardware** provided (player must have PC)
- Limited number of games support local multiplayer over the network

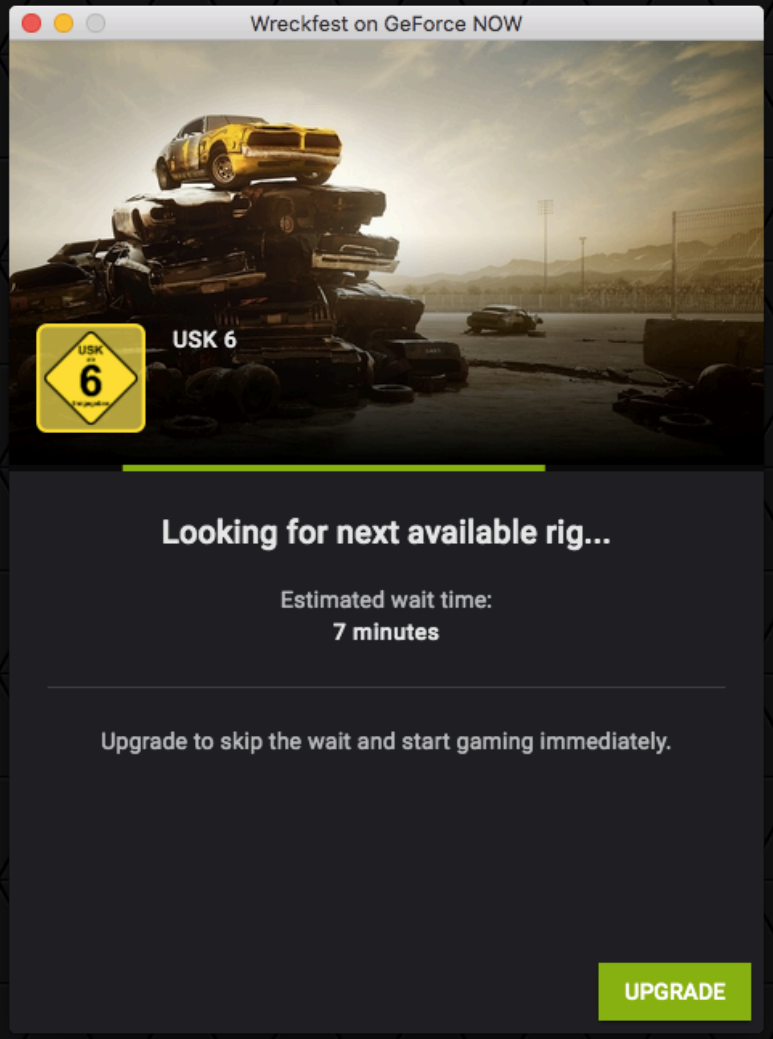

Steam
STORE
LIBRARY
COMMUNITY
HOME
GAMES AND SOFTWARE
RECENT (14)
Wreckfest
Barotrauma
FaceRig
Remnant: From the Ashes
Deep Rock Galactic
A Way Out
Blender
Ori and the Blind Forest: Definitive I
Krita
Halo: The Master Chief Collection
Risk of Rain 2
Kung Fury: Street Rage
Satisfactory
Dungeons 3
WRECKFEST
DRIVE HARD, DIE LAST
STREAM
LAST PLAYED
Today
PLAY TIME
168 hours
ACHIEVEMENTS
14/20
Store Page
Community Hub
Find Groups
Discussions
ACTIVITY
Say something about this game to your friends...
View Latest News
FRIENDS WHO PLAY
1 friend has played recently
ABuyz
2 hrs played recently
ADD A GAME
DOWNLOADS
Manage
FRIENDS
& CHAT

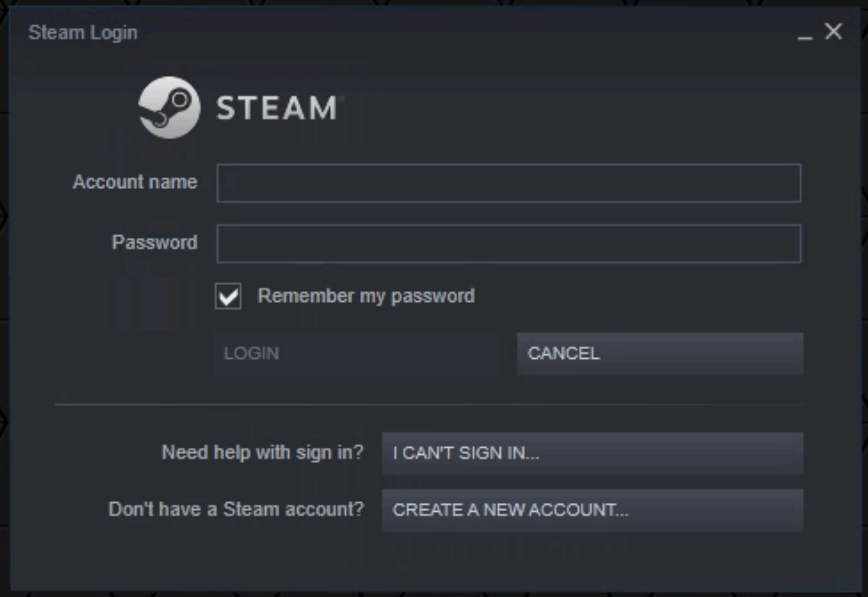

Steam Remote Play
pc is available for streaming

GeForce NOW

[NVI20a]

- **Cross-platform** (Mac, Windows)
- Available on **mobile** (Nvidia shield, Android)
- **Free** 1-hour play-time period (longer wait times)
  subscription-based otherwise
- **Hardware provided** (with RTX-based GPU)
- A **limited subset** of purchased games
  Steam, Epic Games Launcher, Uplay
- Integrated Shadowplay service
  automatic replay recording in supported games

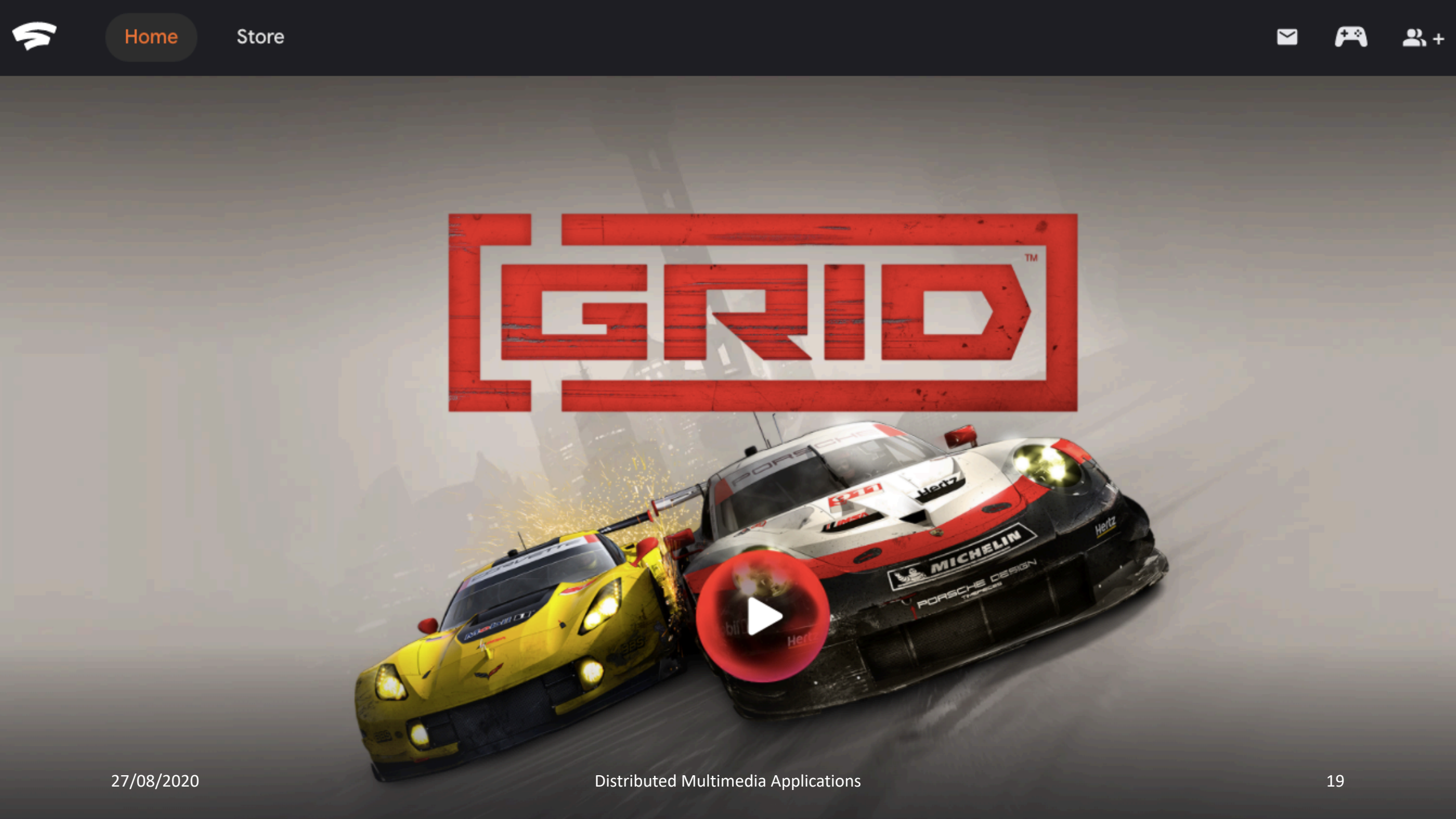

Wreckfest on GeForce NOW
USK 6
Looking for next available rig...
Estimated wait time:
7 minutes
Upgrade to skip the wait and start gaming immediately.
UPGRADE


Steam Login
STEAM
Account name
Password
Remember my password
LOGIN
CANCEL
Need help with sign in?
I CAN'T SIGN IN...
Don't have a Steam account?
CREATE A NEW ACCOUNT...

Google Stadia

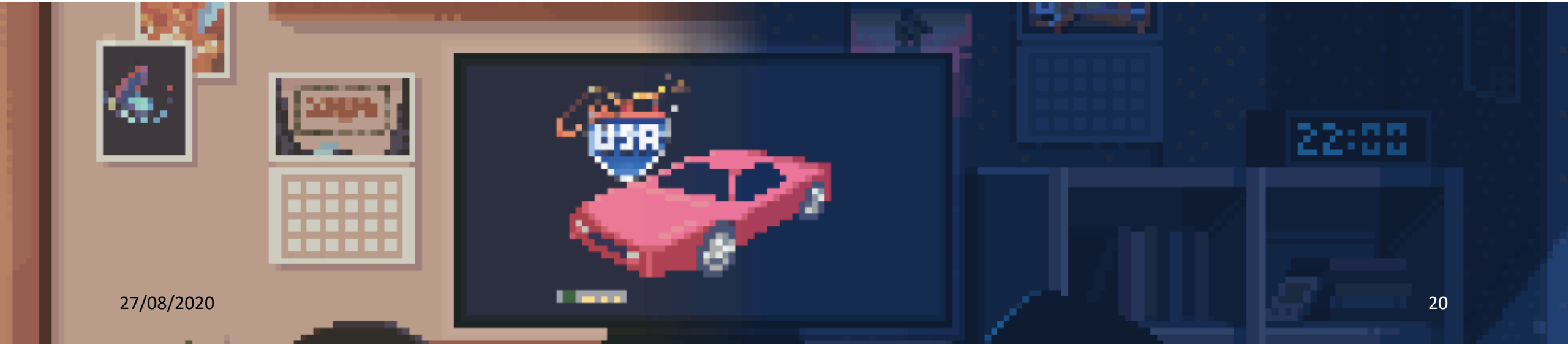
[Goo20]

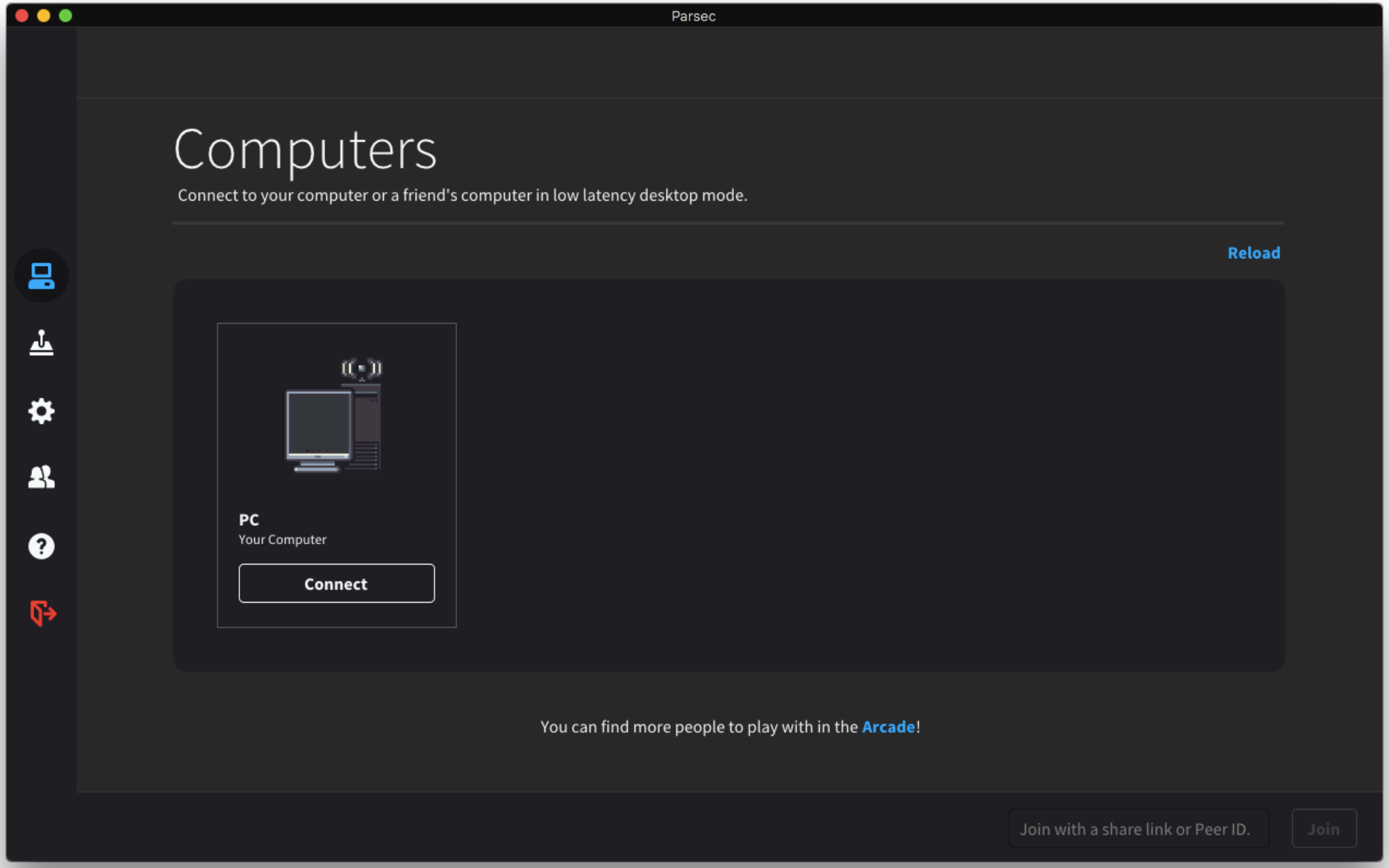
- **Cross-platform** (Chrome web-browser)
- Available on **mobile** (**limited** number of Android smartphones)
- **Hardware provided**
- **Subscription-based** (credit-card required for registration)
- **Very small** amount of games (around 50 currently)
- **Must purchase** games again even if already owned

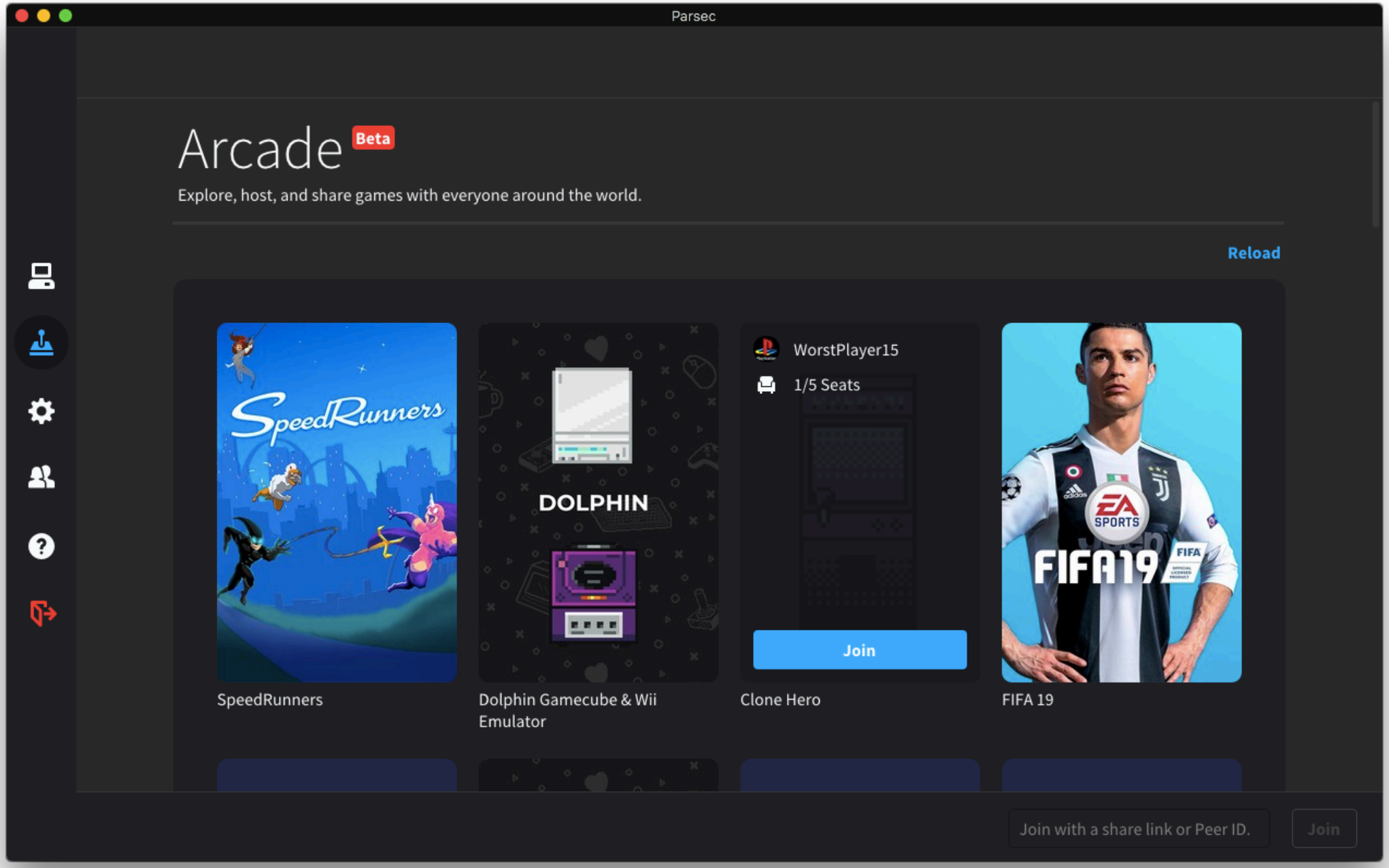

Home
Store
GRID
MICHELIN
Hertz

Parsec
[Par20]

- **Cross-platform**
  Mac, Windows, Linux, Android, Raspberry Pi 3, Chrome browser
- **Hosting** only supported on Windows 8.1+
- **No hardware** provided
- **Free** for personal use
- Can stream both **games and desktop**
- Some troubles with full-screen capture
- Local multiplayer over the network

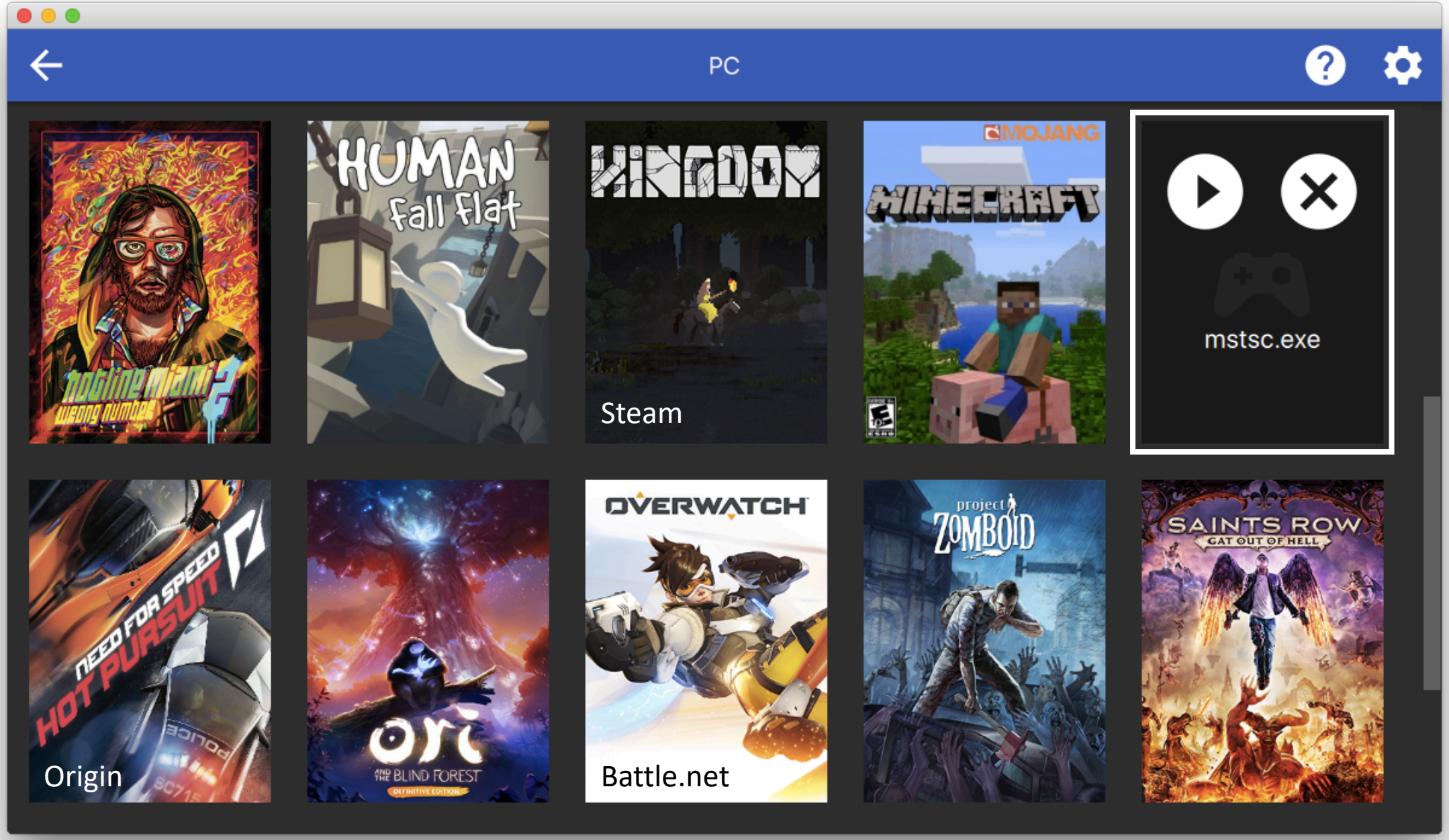



Parsec
Computers
Connect to your computer or a friend's computer in low latency desktop mode.
Reload
PC
Your Computer
Connect
You can find more people to play with in the Arcade!
Join with a share link or Peer ID.
Join


Parsec
Arcade
Beta
Explore, host, and share games with everyone around the world.
Reload
SpeedRunners
DOLPHIN
WorstPlayer15
1/5 Seats
Join
FIFA19
SPORTS
FIFA
SpeedRunners
Dolphin Gamecube & Wii Emulator
Clone Hero
FIFA 19
Join with a share link or Peer ID.
Join

Moonlight
[Moo20]

- **Open source** NVIDIA GameStream client
- Created by students from Case Western Reserve University during a hackathon
- **Cross-platform** (Windows, Mac, Linux, Raspberry Pi and more)
- Available on **mobile**
- **No hardware** provided
- Can stream both **games and desktop**
- Nvidia shield **game library**
- Setup can become **cumbersome** (port forwarding)
- First released in 2013 – now seems to be obsolete


PC
Hotline Miami 2
Wrong Number
HUMAN
Fall Flat
KINGDOM
Steam
MOJANG
MINECRAFT
mstsc.exe
NEED FOR SPEED
HOT PURSUIT
Origin
ori
AND THE BLIND FOREST
DEFINITIVE EDITION
OVERWATCH
Battle.net
project
ZOMBOID
SAINTS ROW
GAT OUT OF HELL

Experiments

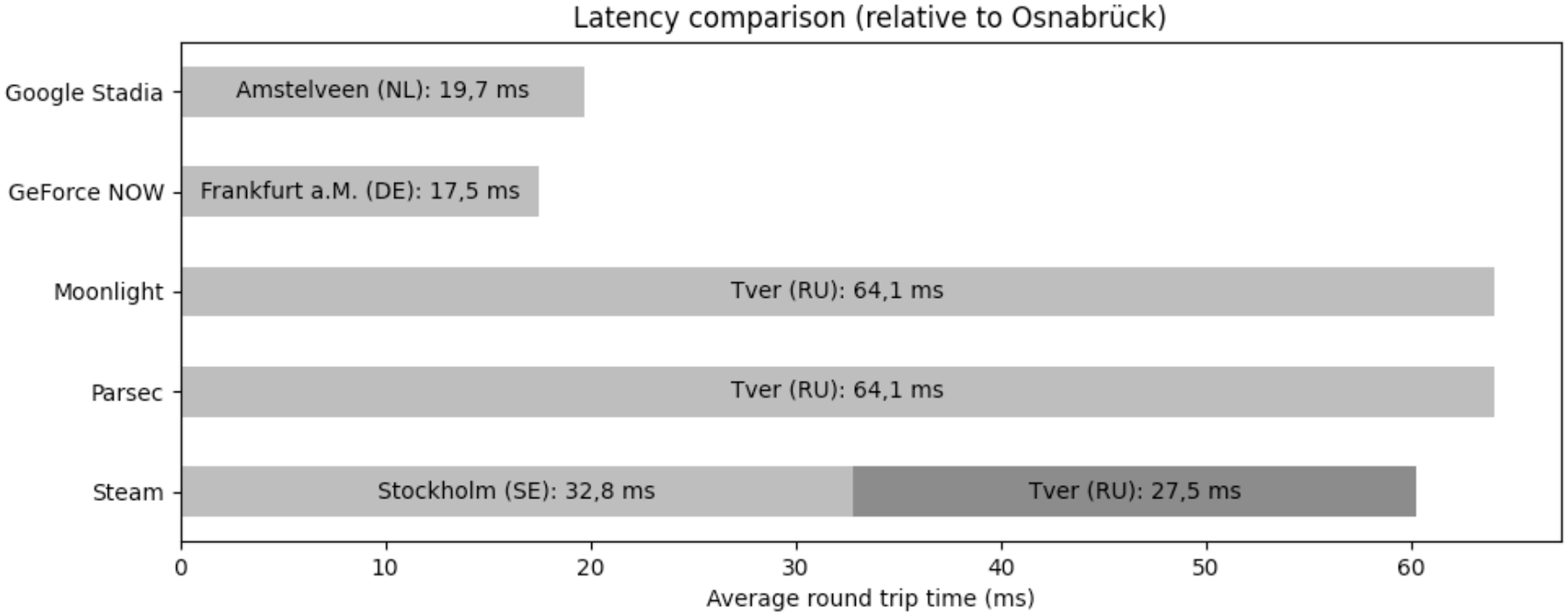
- Adaptation patterns
- Responsiveness

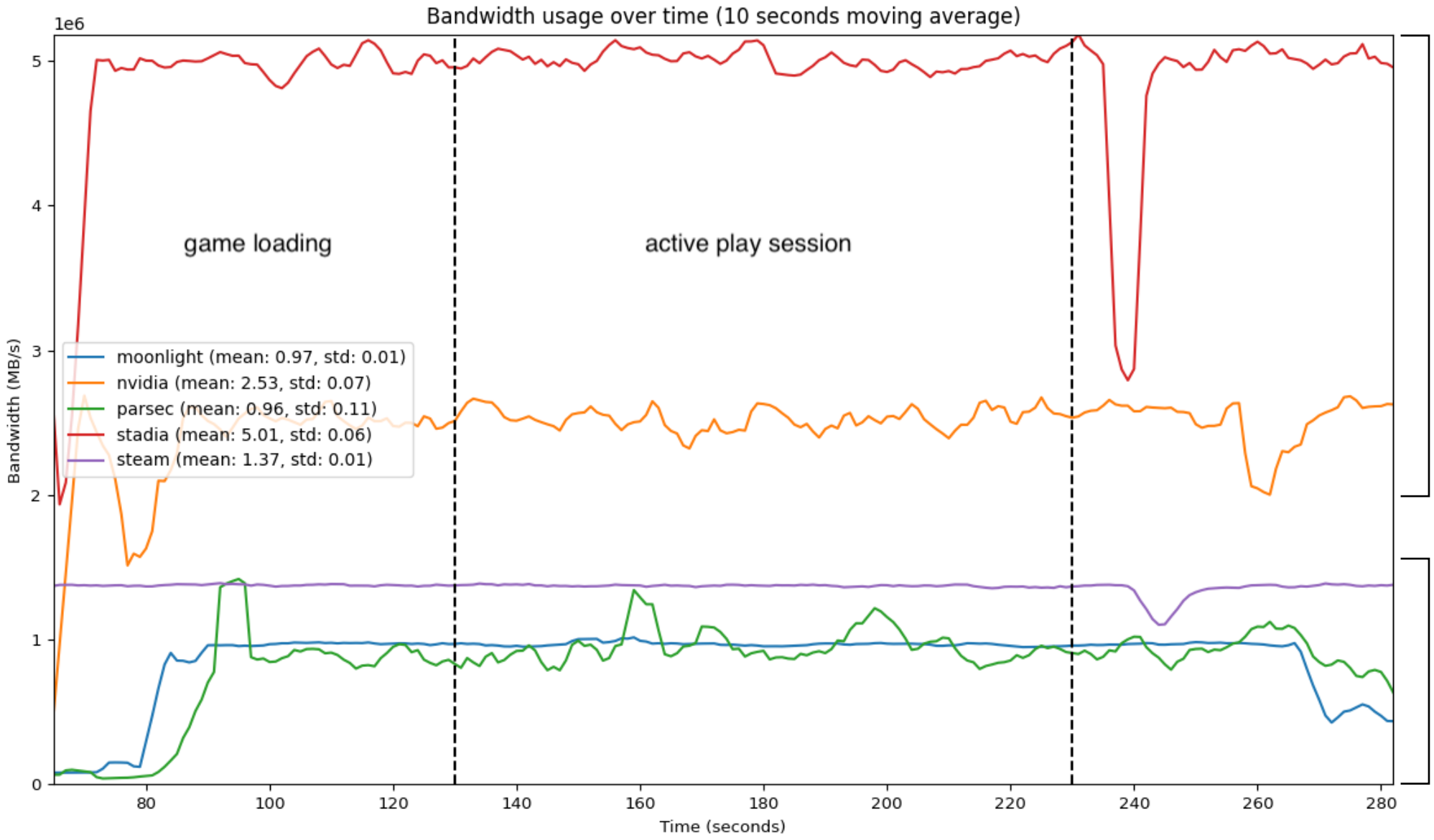
Choice of the service can be affected by the distance and size of the country:

- Lower latencies across the Europe
- Higher latencies from Europe to further away countries (i.e. Russia) make noticeable difference in user experience

Endpoints were discovered using *Wireshark*

100 Mbit/s 5GHz Wi-Fi was used

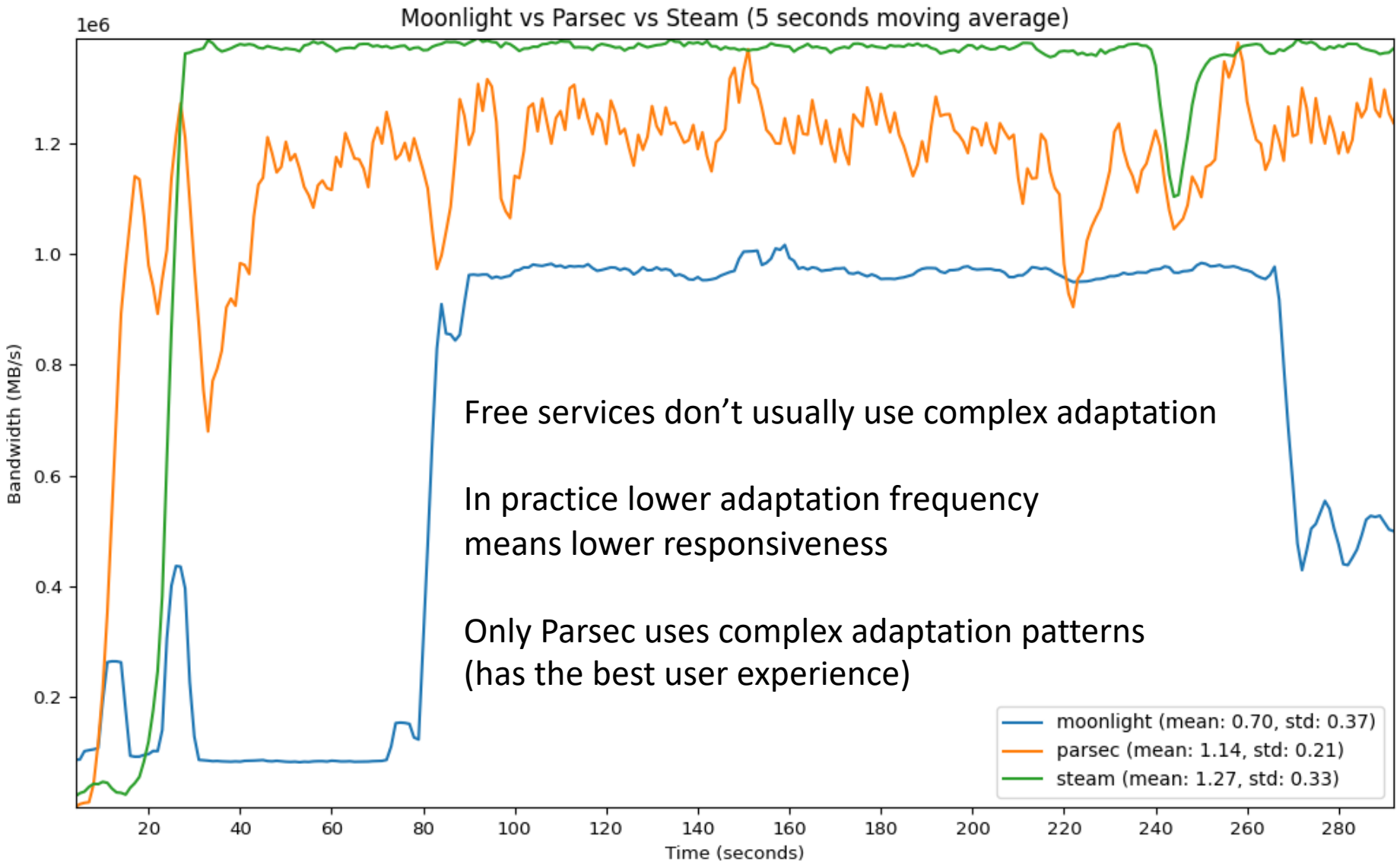




hardware provided

self-hosted

Self-hosted service comparison



Free services don’t usually use complex adaptation

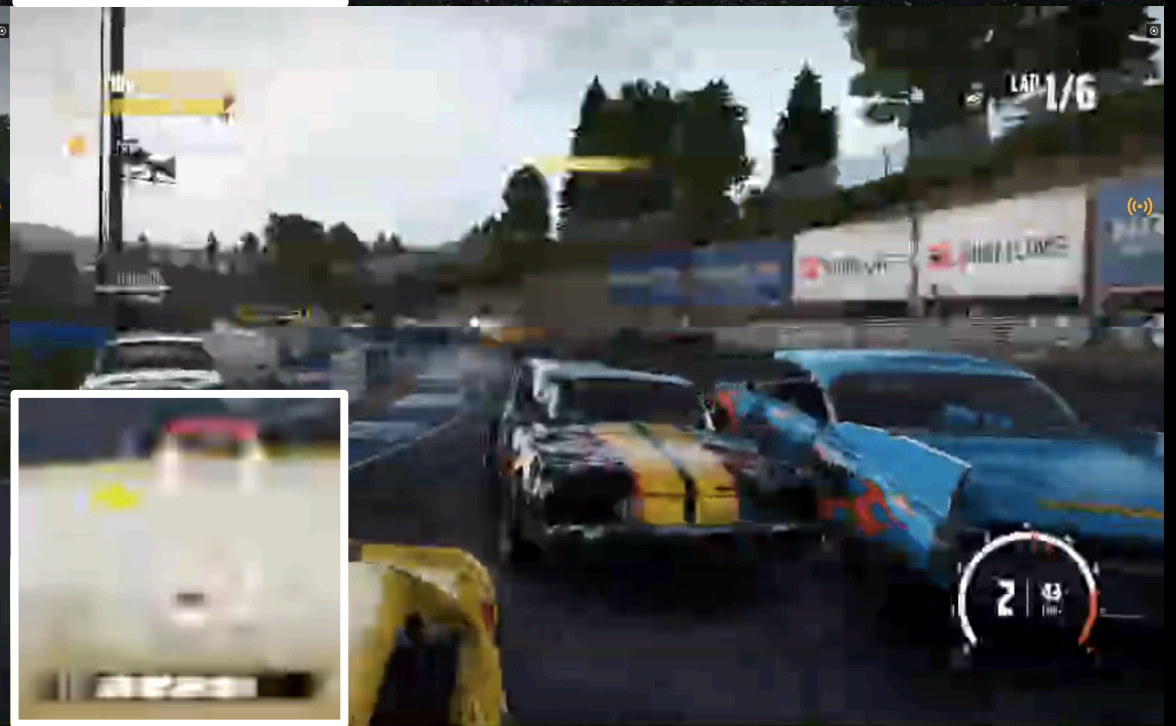
In practice lower adaptation frequency
means lower responsiveness

Only Parsec uses complex adaptation patterns
(has the best user experience)

00:03:07
3/24
4

Game is playable even with low bitrate

Complex adaptation patterns prioritize input responsiveness



Comparison

	Paid		***Free***		
	GeForce NOW	*Google Stadia*	*Steam Remote Play*	*Parsec*	*Moonlight*
Bandwidth used	**2,5 MB/s**	5,0 MB/s	1,4 MB/s	**1,0 MB/s**	**1,0 MB/s**
Bandwidth adaptation	**Yes**	**Yes**	No	**Yes**	No
Round trip time (Osnabrück – Tver for free services)	**17,5 ms**	19,7 ms	**60,3 ms**	64,1 ms	64,1 ms
Responsiveness	**High**	**High**	Medium	**High**	Low *30 FPS only*
Number of games	**2,000**	50	30,000+	**unlimited**	**unlimited**
Local multiplayer	No	No	Some games	**Yes**	No

Summary

- Highlight of **previous research**
- **Currently available** services reviewed
- Small test carried out to show adaptation capabilities of the services
- Comparison was shown

Outlook

Benefits from such services:

- **Higher centralization** – majority of the games can be played almost on all platforms (consoles, mobiles, PC)
  - More flexibility
  - Affect game quality (on mobile market) *ability to play AAA games on your phone*
- *Speculation:* further **migration** from **subscription-based** business model to "pay for what you use"? (like AWS)

Thank you!

References

[Che11] Chen K.T.; Chang Y.C.; Tseng P.H. et al. (2011): Measuring the latency of cloud gaming systems. In: *Proceedings of the 19th ACM international conference on Multimedia*.. S. 1269-1272.

[Goo20] Google: *Stadia - One place for all the ways we play*. https://stadia.google.com/, zuletzt geprüft am 03.08.2020.

[Lee12] Lee Y.T.; Chen; K.T. et al. (2012): Are All Games Equally Cloud-Gaming-Friendly? An Electromyographic Approach. In: *11th Annual Workshop on Network and Systems Support for Games (NetGames)*. IEEE.

[Moo20] *Moonlight Game Streaming: Play Your PC Games Remotely*. https://moonlight-stream.org/, zuletzt geprüft am 03.08.2020.

[NVI20a] *NVIDIA GeForce NOW*. https://www.nvidia.com/en-us/geforce-now/, zuletzt geprüft am 29.07.2020.

[NVI20b] *Accelerated Virtual Desktops for Mobile and Office Workers | NVIDIA Virtual GPU Solutions*. https://www.nvidia.com/en-us/data-center/virtual-gpu-technology/, zuletzt geprüft am 03.08.2020.

[Par20] Parsec Gaming: *Game, Work, and Play Together From Anywhere | Parsec*. https://parsecgaming.com/, zuletzt geprüft am 29.07.2020.

[Suz16] Suznjevic M.; Slivar I. und Skorin-Kapov L. (2016): Analysis and QoE Evaluation of Cloud Gaming Service Adaptation Under Different Network Conditions: the Case of NVIDIA GeForce NOW. In: *Eighth International Conference on Quality of Multimedia Experience (QoMEX)*. IEEE.

[Val20] Valve Corporation: *Steam Remote Play*. https://store.steampowered.com/streaming/, zuletzt geprüft am 29.07.2020.

[Yad17] Yadav H. und Annappa B. (2017): Adaptive GPU resource scheduling on virtualized servers in cloud gaming. In: *Conference on Information and Communication Technology (CICT)*. IEEE.

[Zad18] Zadtootaghaj S.; Schmidt S.; Barman N. et al. (2018): A Classification of Video Games based on Game Characteristics linked to Video Coding Complexity. In: *16th Annual Workshop on Network and Systems Support for Games (NetGames)*. IEEE.