Literature Review

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This document keeps track of all the literature I look at while researching my honors thesis.

Table of Contents

Legend

Formal references

1. Reference (APA Style) (Generate using Scribbr citation generator)
2. Notes

Example

Brown, D. (2022, September 6). *When to use a VPN—And when it won't protect your data*. The Wall Street Journal. https://www.wsj.com/articles/vpn-data-protection-privacy-tips-11662155750?mod=Searchresults_pos5&page=1

Brown claims VPNs can sometimes protect your data. He uses logical appeals to get the reader to agree with him by plainly stating scenarios for which a person would use a VPN and whether their data would be protected. This is good because a person can easily find out if they should use a VPN for their situation.

Informal references

When viewing multiple links that connect each other, I will just include the links inside the notes, to improve the efficiency of the literature review. When I write the actual thesis, I *will* provide proper references.

Example

- Reddit open source recommendations Reddit user *omigot* recommended Mindustry
  - Mindustry is an automation tower defense real time system (RTS) game.
    - Side note: RTS is distinguished from turn-based strategy (TBS), in which all players take turns when playing. (https://github.com/topics/rts)

Here I included three links discussing how I found the game, a link to the game's repo, and a link to a definition used.

Initial Research

Popular mobile only multiplayer games

Erhard, V. (2022, July 28). *8 best multiplayer mobile games that can't be played anywhere else*. Game Rant. Retrieved September 20, 2022, from https://gamerant.com/best-mobile-only-multiplayer-games/

1. Doodle Army 2
   a. Android & iOS
   b. Shooter
   c. Up to 6 other players in real time
   d. Invite friends and play custom games together
   e. Play against strangers
   f. 20 maps
   g. Variety of weapons to choose from
   h. Challenging to beginners, high skill ceiling
2. Kingdom Maker
   a. Android & iOS
   b. Open world
   c. Casual strategy game
   d. Build your own kingdom
   e. Engage in battle and conquer new territories
   f. Build and protect your own kingdom
   g. Compete in real-time combat
   h. Gossip about other kingdoms
   i. Use diplomacy
   j. Get married and create a family
   k. Team up with friends
   l. Join alliances
3. Raft Survival: Multiplayer
   a. Android
   b. Survival adventure
   c. Open world
   d. Explorable with friends
   e. Build a raft and try to survive only by using catches from the ocean and crafted items
   f. Wide variety of weapons and armor aresenal
4. Tap Titans 2: Idle Clicker RPG
   a. Android & iOS
   b. Fight against gigantic titans
   c. Single player focus, with multiplayer clan raids option
   d. Build skills to take on more difficult monsters
5. Mario Kart Tour
   a. Android & iOS
   b. Single-player and multiplayer
   c. Race against friends and strangers from anywhere on Earth
   d. Variety of karts and outfit customization
6. Fun Run 3
   a. Android & iOS

      b.   Competitive multiplayer animal racing
      c.   Race in real-time
      d.   Arena gameplay option with 8-player racing mode
      e.   Leaderboard
      f.   Clans with friends or random players to show off unique style during fashion shows

7. Brawl Stars
   a. Android & iOS
   b. Multiplayer hero fast-paced shooter
   c. Single or multiplayer
   d. Unlock and upgrade powerful Brawlers and gadgets
   e. Quests
   f. Maps, skins, and game modes
8. Pokémon Go
   a. Android & iOS
   b. Real-life adventure
   c. Can play in any location
   d. Battling other Pokémon Go trainers
   e. Competing in gym battles
   f. Teaming up with other trainers to catch more powerful Pokémon.
   g. Unique gaming experience

Open-source mobile multiplayer games

Searching…

- Viewed Source Forge - Open-Source Multiplayer Games on Android, but didn't find any good results.
- Source Forge - Open-Source Multiplayer Games has good results, however, most results are for Windows, Mac, or Linux, not for mobile.
- opensource.com android games didn't have any multiplayer games

Found Mindustry:

Reddit open source recommendations Reddit user *omigot* recommended Mindustry GitHub

- Mindustry is a sandbox tower defense real time system (RTS) game.
  - Side note: RTS is distinguished from turn-based strategy (TBS), in which all players take turns when playing. (https://github.com/topics/rts)
- https://mindustrygame.github.io/. Mindustry's website states players can "build and fight with other players on multiplayer servers."
- https://play.google.com/store/apps/details?id=io.anuke.mindustry
  - Play with friends in cross-platform multiplayer co-op games and team based PvP matches.

Idea: Look at multiplayer game repos on GitHub using Topics feature

Mindustry

https://anuke.itch.io/mindustry

- Open-source mobile multiplayer game
- Android, iOS, Windows, MacOS, Linux

- Multiplayer is different for Steam than other platforms.

How Mindustry's multiplayer works

Sources: Playing the game, https://mindustrygame.github.io/wiki/faq/,

Mindustry allows players to host and join servers locally, remotely, and globally. The developers do not set up their own servers. It is all done by the players. It is cross-platform, so pc can play with mobile.

Instructions for hosting a local area network (LAN) server through the game:

1. Start a game
2. Press the menu icon in the top left corner
3. Press Host Game
4. Type the name of your server and choose a color.
5. Press the host button to host a server on port 6567.
- Anybody on the same Wi-Fi or local network should be able to see your server in their server list.
- If you want people to be able to connect from anywhere by IP, port forwarding is required.
- Note: If someone is experiencing trouble connecting to your LAN game, make sure you have allowed Mindustry access to your local network in your firewall settings. Note that public networks sometimes do not allow server discovery.

Joining any server (LAN; WAN: Community server, remote server):

- Here, you can enter a server IP or discover local network servers and global servers to connect to. Both LAN and WAN multiplayer types are supported.
- If you want to connect to someone by IP, you will need to ask the host for their IP, which can be found by googling "my IP" from their device.

Joining a server on LAN (public network, Wi-Fi hotspot, IP)

- Can't find the game? Try using a Wi-Fi hotspot instead of a public network.
- If this doesn't help, try connecting directly via IP.
  - From the main menu, press Play > Join Game > Add Server and type in the host's IP address.

Problems

- Hosting and joining on eduroam: This does not work on eduroam. I had to use a mobile hotspot to connect to my other device's server. It's possible that eduroam doesn't allow server discovery.

Difference between LAN and WAN

Mumford, A. (2019, July 15). What's the difference between a LAN and a WAN? *Purple*. Retrieved September 22, 2022, from https://purple.ai/blogs/whats-the-difference-between-a-lan-and-a-wan/

Local Area Network (LAN) is a network that covers a small geographical area such as homes, offices, and groups of buildings.

Wide Area Network (WAN) is a network that covers larger geographical areas that can span the globe.

- Example: The internet. Which is a collection of tens of thousands of networks that connects tens of billions of devices.

LAN is faster than WAN because the data has a shorter distance to travel.

LAN is more secure than due to how WANs transmit the data and how far the data would need to travel.

A WAN is usually not owned and maintained by a single organization/entity like LANs are, therefore, you have much less control over the network. However, you can secure your data better using a VPN.

An obvious advantage that WAN has over LAN is the size of the area that it can cover.

Choosing the right netcode framework for multiplayer implementation

House, B. (2020, September 8). Choosing the right netcode for your game. Unity Blog. Retrieved September 24, 2022, from https://blog.unity.com/technology/choosing-the-right-netcode-for-your-game

In this informative article based on the research of the Unity team, House attempts to provide an "in-depth overview" of choosing a netcode framework for building a multiplayer game in Unity. Using data from a survey of 200+ Unity users, 20 in-depth interviews, and learnings from prototypes, House's team created tools to help guide readers through the process of choosing a framework. These tools consider customer feedback based on six aspects: **stability/support, ease of use, performance, scalability, feature breadth, and cost**.

The information is reliable given it is presented by the Unity team itself, the ones who work for the game engine company. This is a useful source because it is a source of primary information based on research they conducted. They provide their criteria for grading frameworks and are unbiased by not picking a "best in category" option. This source will be helpful for my research for this project because it provides a high-level guide to start evaluating which multiplayer implementation is right for my game type.

Understanding network topology configurations

Network Topologies | Unity Multiplayer Networking. (2022, May 4). Retrieved September 24, 2022, from https://docs-multiplayer.unity3d.com/netcode/current/reference/glossary/network-topologies/index.html

This webpage is from Unity's documentation on Multiplayer Networks. It defines network topology and provides information on the five configurations of network topologies.

This information is reliable because it is a part of the documentation for Unity, a well-respected game engine. To change the documentation, a person must propose their changes via GitHub and receive a peer review by a Unity Technologies employee. This source will be helpful for my research because it provides definitions of network topology configurations, which I will determine and analyze for each game I evaluate.

Williams, L. (2022, August 13). Types of Network Topology: Bus, Ring, Star, Mesh, Tree Diagram. Guru99. Retrieved September 24, 2022, from https://www.guru99.com/type-of-network-topology.html

In this informative article, Williams explains what topology is, the types of network topology: physical and logical, and the seven types of logical network topologies. With each logical network topology, Williams includes its advantages and disadvantages. He also discusses some important considerations for selecting the best topology to create a network in an organization.

This article will contribute to my research by providing a high-level overview of network topologies and how they work. I can use this knowledge to understand better the multiplayer network topologies described by the Unity Multiplayer Networking documentation.

Cloud services in gaming

Bajpai, P. (2021, February 24). How cloud computing is changing the world of games and gaming. Nasdaq. Retrieved September 24, 2022, from https://www.nasdaq.com/articles/how-cloud-computing-is-changing-the-world-of-games-and-gaming-2021-02-24

In this informative article, Bajpai discusses how cloud computing is changing the gaming world by providing an overview of cloud gaming and how it's evolving. She explains that cloud gaming is like "Netflix for games." She lists major companies that have released cloud gaming services for consumers and developers.

The information is reliable because it is on NASDAQ, a reputable website, and the author includes many references. This article may benefit my research because the multiplayer games I'm evaluating may use some of these cloud services.

Essential backend features for multiplayer mobile games

Khatri, S. (2022, September 1). Game Backend Services | Flentas Technologies. Flentas. Retrieved September 24, 2022, from https://www.flentas.com/key-backend-services-for-games

In this informative article, Khatri breaks down what mobile game backend services are and lists the types of services found in successful games. She comes up with two types of services, functional and operational, to better organize these services. The player utilizes functional services, while the game developer/studio utilizes operational services.

The information in this article doesn't seem as reliable as the other sources because it doesn't include any references. However, the site, Flentas, has a partnership with Amazon Web Services, which increases its credibility. This article may be beneficial when evaluating multiplayer features.

Overview of the breadth of real-time multiplayer technologies

undefined [Unity]. (2018, November 19). *Connected Games: Building real-time multiplayer games with Unity and Google - Unite LA* [Video]. YouTube. Retrieved September 24, 2022, from https://www.youtube.com/watch?v=CuQF7hXlVyk

Connected Games "Levels"

Level 1: Dynamic Single Player

- Incentives/Rewards
- Competition/Cooperation
- Example: Angry Birds 2

Level 2: Turn-based Multiplayer

- People Interaction
- Game State Management
- Example: Hearthstone

Level 3: Real-time multiplayer

- Real-time multiplayer tech
- Community vs Toxicity
- Example: Titanfall 2

Level 4: Persistent Game Spaces

- Persistent World Tech
- Example: Crowfall

Real-time Multiplayer Core Challenges
- Latency
  - How responsive does the game need to be?
- Scale
  - How many concurrent players?
- Security
  - How easy is it to hack?
  - Does it put other players' systems at risk?
- Cost
  - Reasonable cost per user for profitability
- Complexity
  - How complex is the entire stack?
  - How much engineering work is going to be required?
- Reach
  - How many people will you get to use your game?
  - How far away are those people?
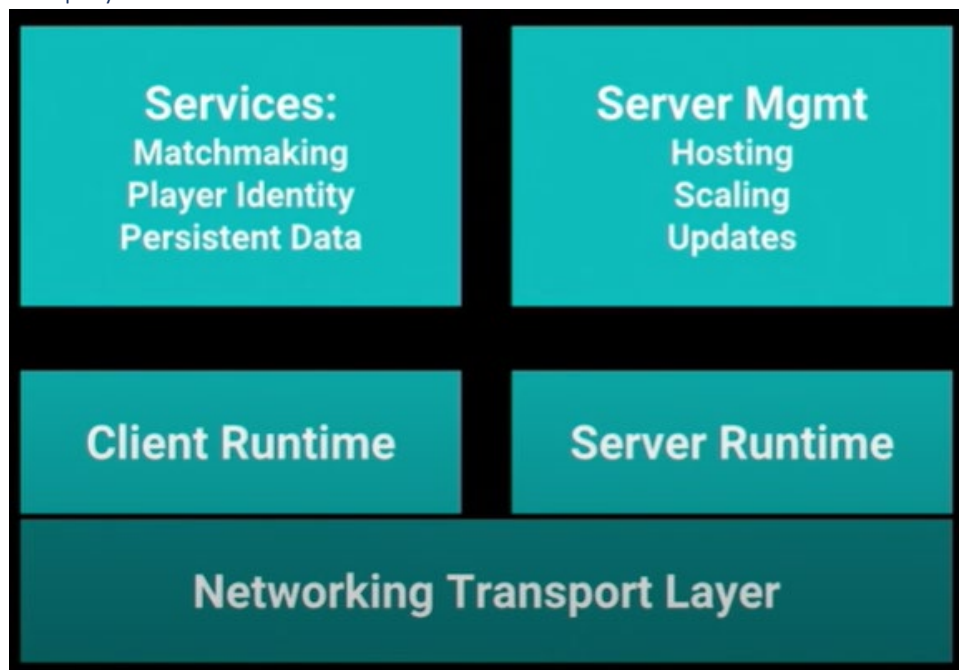
Real-time Multiplayer Software Stack

Figure 1. Real-time Multiplayer Software Stack - Connected Games Unite LA

Networking Transport Layer: The piece communicates most closely with your hardware. It sends the bits back and forth over your internet connection.

On top of networking transport layer:

- Client Runtime
    - Unity is the game client runtime
    - All the additional code that's happening on the client
- Server Runtime
    - Unity could also be the game server runtime
    - All the additional code that's happening on the server

On top of client runtime:

- Services
    - Matchmaking
        - Match players together
    - Player Identity
        - Uniquely tell which player is coming in at each time
    - Persistent Data
        - Stored info about the players

On top of server runtime:

- Server Management: Managing game servers
    - Hosting: Where are they hosted?
    - Scaling: Are they staying up?
    - Updates: When and how are they being updated?

The stack can get complicated

Network Topologies
Network Topology: The concept of which of these pieces exist and how they are all tied together

1. Local ("couch" multiplayer) - Client Runtime
   a. Playing on a single machine
   b. Simplest networking perspective

c. Literally just a client runtime but you're processing multiple input
d. Downsides: Usually, no more than 4 people and limited to people being together
e. Example: Call of Duty's split screen

Latency	✓✓✓	ideal; no networking
Scale	✗✗	typically ≤4
Security	✓	low risks
Cost	✓✓	free
Complexity	✓✓	simplest stack
Reach	✗✗	in-person limits

Figure 2. Local Scorecard - Connected Games Unite LA

2. LAN Games (offline) - Client Runtime, Networking Transport Layer, Server Runtime
    a. Good for VR games since lag can cause sickness
    b. Connects multiple devices (client runtimes) through the networking transport layer to a server (server runtime)
    c. Same space connected through a network. Doesn't require an internet connection.

Latency	✓✓	great; negligible latency
Scale	✓✓	large (100+) with server
Security	✓	low risks
Cost	✓✓	free
Complexity	✓	relatively simple stack
Reach	✗✗	in-person limits

Figure 3. LAN Scorecard - Connected Games Unite LA

3. Peer-to-Peer (P2P) - Client Runtime with Services: Relay and Matchmaking, Networking Transport Layer, Server Runtime
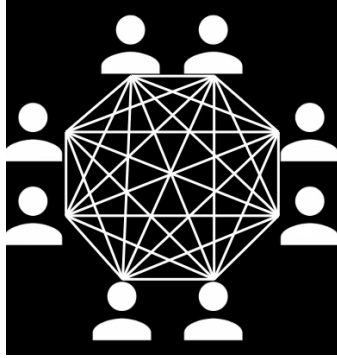   a. Three variants
    b. Direct P2P

Figure 4. Direct P2P - Connected Games Unite LA

    i. Every player connects to every player
    ii. Most straightforward
    iii. Puts the most processing challenge on each of those clients
        1. Each client takes *n* different inputs from *n* different players
        2. Processes and synchronizes at the same time
        3. Logic is challenging

c. Client-Server Host

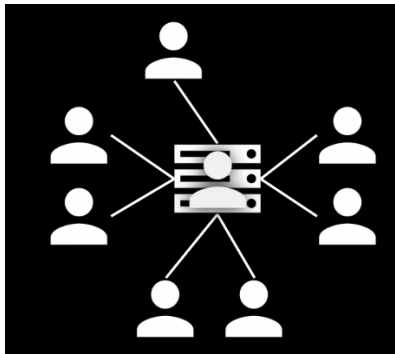*Figure 5. Client-Server Host - Connected Games Unite LA*

    i. One player is the host, one client runtime is chosen to be run as a server runtime
    ii. Everyone connects to that one player
    iii. Traffic is centralized
    iv. The host must process all the data
        1. They get a host advantage because they don't have to send any data out, therefore, getting no latency
    v. If the host quits the game, then the game is dropped, or you must migrate everyone to a new host (host migration).
        1. Which is a terrible user experience (UX)
            a. Game must pause, re-establish connections, get everyone synchronized, then start again and hope it all works.
        2. It's also terrible developer experience to build it

These two methods rely on the players' ability to connect to each other. Firewalls can make this difficult. Even with NAT punch through, the estimated reach is about 80%-90%. 10%-20% of players have a bad experience. A secure service relay can fix this problem.
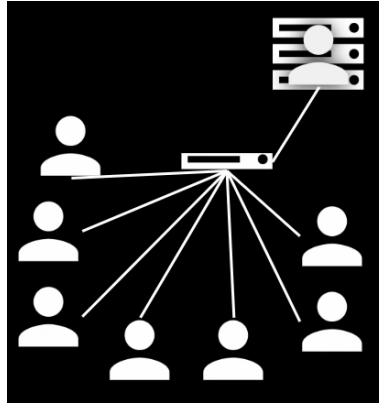
    d.   Client-Server Host w/ Relay (UNet)

Figure 6. Client-Server Host w/Relay - Connected Games Unite LA

    i.   Unity's prior multiplayer stack used this
    ii.   Relays data back and forth
    iii.   Downside: Adds latency, data must travel further

	Direct P2P		Client-Server "Host"		Client-Server Relay (UNet)	
Latency	✓ ✗ ✗ ✓	fast if players close varies per player consumer internet no host advantage	✓ ✓ ✗ ✗	fast if players close fairly consistent consumer internet + HW host advantage	✗ ✓ ✗ ✗	latency to/from relay added fairly consistent consumer internet + HW host advantage
Max Scale	✗	typically 8-12	✗	typically 10-20	✗	typically 10-20
Security	✗ ✗ ✗	cheating/hacking IP's exposed	✗ ✗ ✗	cheating/hacking IP's exposed	✗ ✗ ✓	cheating/hacking host only sees Relay's IP
Cost	✓	cheap - just MM	✓	cheap - just MM	+/-	moderate - MM + Relay
Complexity	+/-	complex N-syncing	+/- ✗	moderate stack host migration difficult	✗ ✗	complex stack host migration difficult
Reach	✗	NAT limitations	✗	NAT limitations	✓	broad reach (if relay covers)

Figure 7. P2P Scorecard - Connected Games Unite LA

There is no one silver bullet with P2P. P2P models are hard to succeed with.

- Latency is inconsistent.
- Security is a challenge: all code is running on a game client
- Scale is a challenge: best case scenario 10-20 players
- Cost: matchmaking service required for finding players that are close, to reduce latency
- Reach: Relay service to reach everyone
- Complexity: Difficult to implement because of synchronization and host migrations.

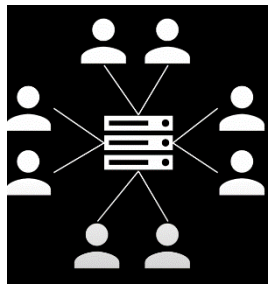4. Dedicated Game Server – Entire Multiplayer Stack

Figure 8. Dedicated Game Server - Connected Games Unite LA

a. Hosted servers that you control, never in the hands of the player
b. You decide how many of them you want distributed throughout the world
c. You decide how fast and consistent the player experience is
d. Server authority to ban/prevent cheaters
e. Downsides: Cost and Complexity

Latency	✓ ✓ ✓	fast if servers close consistent; all equal if similar ping commercial internet connection
Scale	✓ ✓	100+ players with powerful servers
Security	✓ ✓ ✓	cheat prevention - server authority IP's secure
Cost	✗	requires server hosting and services
Complexity	✗ ✗	requires full tech stack
Reach	✓ ✓	can reach all players across the globe

Figure 9. Dedicated Game Server Scorecard - Connected Games Unite LA

Overall best network topology is dedicated game server.

	Local	LAN	Direct P2P	Client-Server Relay (UNet)	DGS
Latency	✓ ✓ ✓	✓ ✓	✗ ✗ ✓ ✓	✗ ✗ ✗ ✓	✓ ✓ ✓
Scale	✗ ✗	✓ ✓	✗	✗	✓ ✓
Security	✓	✓	✗ ✗ ✗	✗ ✗ ✓	✓ ✓ ✓
Cost	✓ ✓	✓ ✓	✓	+/-	✗
Complexity	✓ ✓	✓	+/-	✗ ✗	✗ ✗
Reach	✗ ✗	✗ ✗	✗	✓	✓ ✓

Figure 10. Topology Summary Scorecard - Connected Games Unite LA

Challenges of P2P are inherent. The developers can't change anything about them. However, with DGS, the developers can work to bring down costs and complexity. Services like Amazon Web Services' (AWS) GameKit, Unity Game Services (UGS), and Microsoft's PlayFab strive to bring down the complexity of DGS, so game developers don't have to build everything themselves and can focus on building the game itself.

Strategic Analysis of Turn-Based Multiplayer Games

Turn-based Strategy (TBS)

Definition

Turn-based strategy (TBS) is a popular form of multiplayer games in the video game industry. In TBS, players must strategize and plan to beat their opponent. A popular example of TBS is chess, where players asynchronously take turns to capture the opponent's king and win the game. The key word here is asynchronously. In TBS, players have a defined amount of time, sometimes unlimited, to play a turn. Then the next player plays their turn under the same conditions. This goes on until the game ends under some arbitrary condition specified by the game developers, such as a player completing an objective, time/number of turns running out.

Classification

"Gaming has evolved and exploded in many different directions so the strict definitions of gaming genres and subgenres bleed into each other. You might see a TBS game with real time strategy (RTS) elements or vice versa." (Wilson, 2020)

It can be quite difficult to classify a game as one specific genre. Just like how it can be difficult to classify music. The community and creators both make these classifications. However, the community's classification is usually the one that sticks. A prime example of this is with the artist Post Malone. During his prime, he was most often classified as rapper despite Post Malone stating that he considers himself more of an artist. To this day, when you google "Post Malone", you will get mixed results on whether he is a rapper, a singer, or both. Anyway, when it comes to classifying any type of media, it can be quite the headache.

So, it'd probably be a good idea to come up with some formal definition so I can accurately say this game is a turn-based strategy because it exhibits these specific qualities.

TBS Multiplayer Games
Popular games

1. Polytopia
2. Hearthstone
3. Words with Friends 2
4. Draw Something
5. Fire Emblem: Heroes

Open-Source games

1. Unciv (F-Droid Package) – Open-source implementation of Civilization with multiplayer

2. CrossWords ([F-Droid Package](#)) – Open-source implementation of CrossWords
3. Tribes ([GitHub Repo](#)) – Open-source implementation of Polytopia
- F-Droid is a free and open-source app store. https://f-droid.org/ (Found it in this [Reddit Thread](#))

History

"In 1977 Chris Crawford from Texas was the first to develop a turn-based computer game called *Tanktics: Computer Game of Armored Combat on the Eastern Front*. Strategy games focus on planning rather than rapid actions. Turn-based strategy games take this approach even further, allowing players time to assess the situation before they play their next move carefully. Thus sometimes referred to as "a thinking man's game."" (Israr, 2022)

Israr, U. (2022, September 1). Best Turn-Based strategy games for IOS and android in 2021. *Shadow Knight Gaming*. Retrieved October 4, 2022, from https://www.shadowknightgaming.com/mobile-games/best-turn-based-strategy-games-for-ios-and-android/

Criterium

Networking

- How does the game connect players?
- What topology do they use?
    - What are the pros and cons of this implementation?
    - Use Unity's comparison sheet
        - Latency
        - Scale
        - Security
        - Cost
        - Complexity
        - Reach

Gameplay

- Time per turn
- Objective to win
    - Number of points
    - Fulfill some arbitrary condition
- Number of turns or time until match ends

Unciv

CrossWords

https://xwords.sourceforge.io/index.php

CrossWords is a free open-source implementation of Scrabble. It's available on Android, PocketPC, and PalmOS. It supports multiplayer via Same device, SMS, Bluetooth, and Internet (Relay).

Developer's explanation of how the multiplayer works: [Crosswords FAQ](#)

Set of top turn-based multiplayer game lists

1. https://turnbasedlovers.com/news/video/top-pc-multiplayer-competitive-turn-based-strategy-rpg-games-part-1/ (random ordering)
2. https://www.thegamer.com/best-turn-based-coop-rpg-games/ (12 ranked)

Already within 30 minutes of looking at lists, I can tell I will need to alter my method of collecting data. First, I will need a way to deal with random ordering lists. Also, I want to use Steam's top lists as a way to collect data. So I think I will make a criteria that takes into account different types of lists rather than one specific type of list. I will need to figure out how to weight these accordingly, so that one list is not biased over another list.

Methodology

Method 1

To collect data, I simply played the games. Since they are multiplayer, I used multiple devices to simulate real gameplay. As I played through the games, I took note of how their gameplay mechanics work and how players are connected through the network.

Once I identified their gameplay mechanics. I viewed 20 lists containing the top turn based games. If the game was on the list, then they received a point. The game with the most points was considered to have the best gameplay. If there was a tie, then I considered where on the list the game was placed. For example, if the game was ranked number one, then the game received one point, whereas, if the game was ranked number 7, then the game received 7 points. If the game didn't make the list, then the game receives a score that is the length of the list plus one. So if the list contains the top 10 turn based games, and the game isn't on the list, then the game would receive 10 + 1 = 11 points. The game with the lowest score wins the tiebreaker.

Once I identified a network topology, I used Unity's topology scorecard to give it a score to compare to other games. This scorecard ranks the topology based on how well it handles the following multiplayer challenges: latency, scale, security, cost, complexity, and reach. The scorecard uses checkmarks and Xs display the strength of each challenge. To calculate the score, I add up the checkmarks and subtract the Xs. For example, in figure 1 we can see the scorecard for the local area network (LAN) topology. We can see the topology handles latency, scale, and cost better than it does security, complexity, and reach because it has two checkmarks for latency, scale, and cost versus the one checkmark for both security and complexity and two Xs for reach. So the score for this topology would be 2+2+1+2+1-2=6.

Latency	✓ ✓	great; negligible latency
Scale	✓ ✓	large (100+) with server
Security	✓	low risks
Cost	✓ ✓	free
Complexity	✓	relatively simple stack
Reach	✗ ✗	in-person limits

Figure 11. Local Area Network (LAN) Scorecard - Unity 2018

Method 2

I viewed the first 20 lists I found searching "best turn-based games". I put each game from all the lists into a spreadsheet. Going through each list, if the game was on the list then it received the number of points that it was ranked. For example, if the game was ranked number one, then it would receive one point. If the game wasn't on the list, the it received the number of points of the longest list's length plus 1. For example, if the game wasn't on a list and the longest list length was 20 games, then the game would receive 21 points. Once I went through all the lists and added up all the points, I chose the top 3 games with the fewest points.

After choosing the top 3 games, I identified their network topologies and gameplay mechanics through research first and then playing the game if needed.

This method discovers the most popular gameplay mechanics and network topologies.

Method 3

Get the top two turn-based multiplayer games from Steam, Google Play Store, and iOS App Store top charts. Identify these games' network topologies and gameplay mechanics through research and gameplay.

This method discovers the most popular network topologies and gameplay mechanics of popular turn-based multiplayer games.

Definitions – Might not use these

To understand how the identified gameplay mechanics and network topologies will be useful, we must first define the terms and concepts that will be discussed.

Popular turn-based multiplayer video game

Popular

Multiplayer

Video game

A video game is any game played on a computer.

Examples: Call of Duty, World of Warcraft, Clash of Clans, etc.

Turn-based

Turn-based is a genre of gaming where the players have a period to execute some arbitrary number of functions while the other players wait. Once the period is complete, the player's turn will end, and if it is a multiplayer game, the next player will follow this procedure. This procedure continues until it has exhausted the list of players. Then it returns to the start of the list, i.e., the first player's turn.

Examples: Board games such as Chess, Checkers, Monopoly, etc. Video games such as Sid Meier's Civilization, Worms, Polytopia, etc.
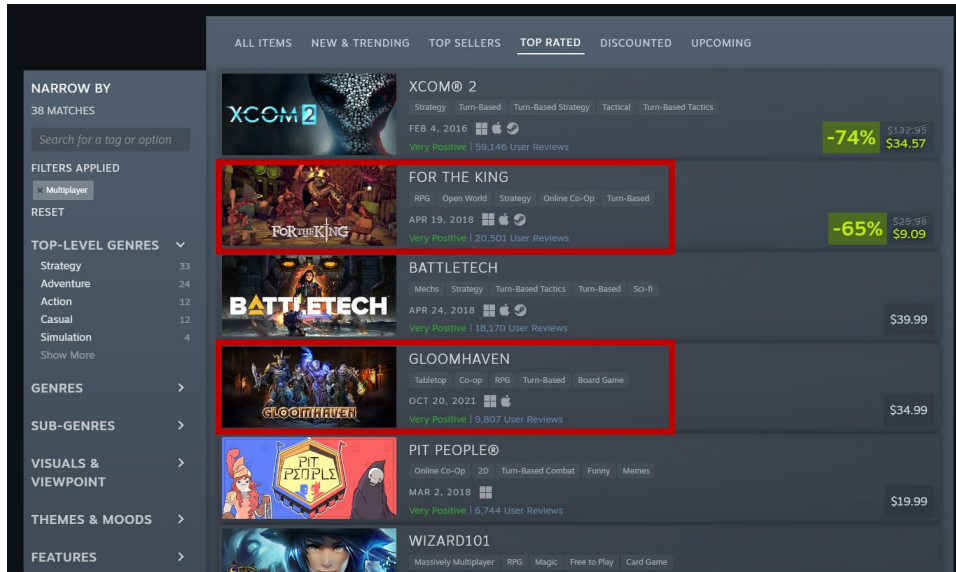
Gameplay mechanics:

Quora post distinguishing gameplay from mechanics

Network topology:

App Store Top Charts (United States – 10/27/22)

Steam

XCOMM 2 no longer supports multiplayer

Battletech's reviews are mostly about its singleplayer mode, thus analyzing its unpopular multiplayer wouldn't produce much fruit for this project.

https://store.steampowered.com/category/rpg_turn_based/?facets13268=6%3A4&flavor=contenthub_toprated

1) For The King
2) Gloomhaven

Steam ranks according to user ratings.

iOS App Store

1) Marvel Snap
2) Meme Challenge: Dank Memes

iOS App Store ranks according to

- Quantity of new users added
- App usage (session frequency and total time spent in-app)
- Velocity of downloads/engagement (assume a 4-7 day moving average is used)

Also ranks according to (at a lesser extent)

- App store rating
- User review volume
- Keyword relevancy
- Uninstalls

Apptopia believes these components are evaluated on a 4-7 day moving average.

https://blog.apptopia.com/app-store-rank-explained-what-is-an-apps-apple-google-store-ranking-and-what-impacts-it

Google Play Store

1) Marvel Snap
2) Monopoly – Classic Board Game

Google Play Store ranks according to

- Listing Performance (how well the app converts first time installs)
- Metadata keywords
- Retention rate (high uninstall rate causes a negative impact on ranking position)
- App ratings, user reviews and feedback.
- Frequency of updates. (Higher frequency = higher rank)
- Backlinks (More backlinks = Higher ranking)
    - A backlink is when one website links to another with an anchor text (https://mailchimp.com/marketing-glossary/backlinks/)
- Technical performance (Including crash rate)

https://www.storemaven.com/glossary/what-is-google-play-ranking/

Both Google Play Store and iOS App Store rankings are per country and the data above collected is based on US Charts.

https://blog.apptopia.com/app-store-rank-explained-what-is-an-apps-apple-google-store-ranking-and-what-impacts-it

Marvel Snap

Price: Free
Platform: iOS, Android, PC

Wikis may be a good source of information for both gameplay mechanics and network topologies.

Gameplay Mechanics

Game mechanics explained: https://www.gamedeveloper.com/blogs/designers-don-t-sleep-on-marvel-snap-s-simultaneous-turns

6 Simultaneous turns

"All turn-based multiplayer games rely on some level of projection or patience for what your opponent is going to do. What Marvel Snap illustrates is that there's a huge difference in how you try to make those guesses when you and your opponent play your cards at the same time."

"When players play their cards at the same time, the only information each of them has is the cards that were played the previous round"

"And with Marvel Snap's three-Location structure, players are also being asked to guess not just what kinds of cards their opponent will play, but where they'll play them. Early cards in the games' starter deck actively encourage new players to start making that judgment call, and it's a call that's easier or harder to make based on what's been played."

Snap - Oh, Snap! https://www.polygon.com/guides/23427096/marvel-snap-beginners-tips-cards-decks-pools-locations

"One of Snap's key mechanics is in its name: the snap. When you snap, you double the amount of cubes (the game's version of ranked points) in play for both players. Snapping only goes into effect after the opposing player completes their next turn — you can't snap in the middle of a turn and have it immediately count – but it's something you want to do when you're feeling confident of winning the matchup. Each player can only snap once per game, and doing it early will increase your rewards if the other player drops out (and could intimidate them into doing so).

"The app is named for the Snap mechanic, which allows you or your opponent to double down at any point during the match. If you win, you get twice the cubes, the currency you use to increase your competitive rank. If you snap and lose, your rank will decrease instead, creating a delicious risk/reward system." - Gameinformer

Retreat - KNOW WHEN TO QUIT

"Because of the snap and cube system, staying in a game that you're losing can be a bad decision. If things aren't breaking your way — maybe the locations synergize poorly with your cards, or maybe your opponent just outplayed you — cut your losses and accept a one-cube defeat, rather than risking losing four or even eight." - Polygon

"The game does a good job in bringing players along, using low-level bots to teach them the ropes before tossing them into the deep end. Outside of the central mechanics, however, there isn't too much to teach. The beauty of Marvel Snap is in its simplicity. At its core, this is a numbers game and the path to victory lies in being able to crunch numbers and solve simple equations. In a nice touch, sometimes the numbers don't lie and they spell disaster, so players are then allowed to retreat before the final turn to keep their losses to a minimum."

No Mulligans

Article about no mulligan

Twitter thread about no mulligan

Ben Brode explains why they switched from a mulligan to no mulligan by changing the quicksilver card, which costs one energy, to always appear in the starting hand.

"Who needs to mulligan when you always draw your 1-drop? Eventually many players decide to swap Quicksilver for a different card, but at that point you're making the *choice* to risk a bad opening hand. In game design, an important question to ask when facing a problem is: Is this a system-design problem, or a content design problem? In this case, what initially seemed like a system problem (players want a mulligan) was actually solved with a content design change!" - Ben Brode on Twitter.

Random Locations

"A big goal we had with Marvel Snap was to add a ton of variance, but focus it on 'Input Randomnes' - where you see the random events *before* you make your decisions. You have more control this way, and it feels more strategically satisfying." - Ben Brode on Twitter

"In a game, you play your cards at one of three iconic Marvel locations, each with a different gameplay modifier. For example, Kamar-Taj allows certain card abilities to trigger twice, Fisk Tower destroys any card that moves there, and the Gamma Lab turns every card into the Hulk. Between the dozens of locations and the vast number of cards, Marvel Snap has so many variables that much of the joy of playing comes from seeing what's going to happen in any given match. I can never predict what will happen the next time I play, and that curiosity is what makes the game so engaging." - Gameinformer

Gameplay Summary

"These two main mechanics – the snap and the random locations – are how Marvel Snap sinks its hooks into me so deeply. It's a game that relies on you to think two steps ahead; you have to plan according to the future locations, your opponent's moves, and what cards you'll draw from your deck, despite the fact that you can rarely know any of those factors. If you feel confident, you snap, raising the stakes.

Maybe you even snap if you aren't feeling confident, just to throw your opponent off their rhythm. It's a guessing game, and when you come out the other side victorious, you feel like the smartest and/or luckiest player alive." - Gameinformer

My experience

Device: SM-S908B/DS
OS: Android 12

- Sign in with Google to create an account.
- Match Search
  - Device vibrates when match is found
  -
- PvP gameplay: 1v1
  - Cards
    - Most cards have a special ability.
      - On Reveal
      - On going
    - Energy cost to be placed down
    - Power amount that determines who wins each location.
  - Locations
    - Three card placement locations. Each location has 4 slots.
    - Each location has a rule.
      - Monster Island
        - Add a 9-Power Monster here for each player
      - Mojoworld
        - Whoever has more cards here gets +100 power.
      - Danger Room
        - Cards played here have a 25% chance to be destroyed.
    - The player with the most power wins the location.
    - If the player wins 2 or more locations, they win the game.
  - Six turns played simultaneously. Press "end turn" when you are finished placing cards.
  - Energy currency
    - Each card has an energy cost that must be met to be placed down.
    - Placing a card uses energy based on its cost.
    - +1 energy per turn (e.g., 1st turn = +1 energy, 2nd turn = +2 energy, 3rd turn = +3 energy)
    - Unspent energy at the end of a turn is wasted.
  - Turn Time
    - When a turn is about to end, the screen edges flash red every 5 seconds.
  - Sound
    - Voice acting from each player
      - During a win
      - If a player is taking a long time to play

- Music is different depending on game mechanic
  - During the turn
  - Ending a turn
  - During a win
- Upgrades
  - Visual Upgrades
    - Frame break makes the card art pop out of the frame.
  - Rarity upgrades
    - Uncommon
      - Cost: 25 Credits 5 Boosters
      - Visual Upgrade: Frame break
      - Collection Level: +1
  - Collection Level
    - Upgrading cards increasing collection level and unlocks new cards
      - Uncommon +1
      - Rare +2
      - Epic +4
      - Legendary +6
      - Ultra +8
      - Infinity +10
- Home screen
  - Shop
    - Welcome Bundle
      - Costs real money (USD)
    - Daily Offer
      - Daily rotation of cosmetics and variants for cards in your collection!
      - Six items for 700 gold each.
    - Fast Upgrade
      - Buy remaining boosters and immediately upgrade your cards!
      - 3 cards for 50 credits each.
      - Auto upgrading cards
        - Every 8 hours, three cards will be chosen at random from your collection.
        - You'll have the opportunity to upgrade these cards by purchasing all remaining Boosters needed with just Credits!
        - Earning more Booster for these cards will lower the price to upgrade at a rate of 1 Booster = 5 Credits.
    - Credits
      - Buy Credits to upgrade more cards. Purchasable a limited number of times per day.
      - Costs Gold
      - 50 free credits per day.
      - 150 credits/120 gold

- 500 credits/400 gold
  - Gold
    - Use Gold to purchase various items throughout the game.
    - Costs real money. (e.g., USD)
    - 300 gold/$4.99
    - 700 gold/$9.99
    - 1450 gold/$19.99
    - 2600 gold/$34.99
    - 3850 gold/$49.99
    - 8000 gold/$99.99
- Collection
  - Decks
    - Can have up to 20 decks!
  - Cards
- Main
  - Play
    - Select deck
    - Rank
    - On first play, you will be asked to enter a name. This can be chosen for you using the "Make Me One" button.
  - Missions
    - Complete them for awesome rewards
    - Weekly Challenge
      - Complete 25 missions
    - Notifications appear when missions are completed or progressed. Tapping them takes you to the mission tab.
  - Tip of the day
    - Who flips first? You can tell from the glowing nameplate!
- Season Pass
  - Free
  - Obtain rewards by earning XP.
  - Each tier requires 1000 XP.
- News
  - Inbox
    - Login Reward
    - Gifts
    - Music played when claim gifts and rewards
  - News
    - How to play
    - Surveys
    - News
    - Community
  - Videos

- o Audio
  - ▪ PvP 1v1
    - • Music
      - o Different depending on game mechanic
        - ▪ During the turn
        - ▪ Ending a turn
        - ▪ During a win
    - • Sound FX
      - o Voice acting from each player
        - ▪ During a win
        - ▪ If a player is taking a long time to play
  - ▪ Home

Network Topologies

Might be useful: https://www.youtube.com/watch?v=CVBTcZf9vFw and https://www.shacknews.com/article/130975/shacknews-e6-2022-marvel-snap-team-talks-design-art-and-more

https://www.shacknews.com/article/132874/marvel-snap-review-ios-android-mobile

Using PCAPdroid on android and Wireshark on pc, I have found that Marvel Snap uses content delivery networks (CDN) to serve the assets. Players can download the asset bundle in the settings if they want to. This can prevent assets from not loading during gameplay if the internet connection is poor. However, this takes up more space on the device. They use the following CDNs:

- • Cloudfront
- • AWS
- • Akamai

Marvel Snap was also built using the Unity game engine. As described here: Marvel Snap Unity Game Engine and as found in the network packets.

In this article, Brode mentions that "The engineering team built a really unique backend where we were able to launch a giant game with no server issues, no downtime, that's kind of unheard of. We just have this unbelievable team." No server issues means that there is use of a server. Likely, a dedicated game server.

Using the packet sniffer, the server I found is "us-east-1-cf.nvprod.snapgametech.com". I think this may be the game server. Its data is encrypted and doesn't trust my TLS decryption certificate, so I have no way of knowing for sure.

Researching thoughts

We likely don't need this much miscellaneous information on the game. Most of this information could probably be found on the Marvel Snap Wiki. What we do need to take note of is how players connect and any unique gameplay mechanics, such as how players play their turns simultaneously rather than one player making a move at a time like Chess.

Network topologies are quite difficult to find online. Especially for Marvel Snap since the game was just released in October 2022, a month ago. I'm finding a ton about gameplay though! Turns out most people care more about gameplay than how players are connected. This makes sense since they are not researching turn-based multiplayer games for networking aspects. They want to know how to be the best at the game.

Reverse Engineering Android Apps
PCAPdroid:

- Monitor network activity.
- Decrypt TLS/HTTPS encryption.

APK Tool:

- Decompile and recompile the APK using APK Tool.
  - Decompiles to Smali code.

APKLab: VS Code extension

- Uses APK Tool and other features to reverse engineer APKs.

This process is taking longer than expected. So, I will icebox it for now and come back later in the project if I have the time.

Monopoly – Classic Board Game
Price: $5.49
Platform: iOS, Android
Developer: Marmalade Game Studio

https://play.google.com/store/apps/details?id=com.marmalade.monopoly

Gameplay Mechanics
https://www.marmaladegamestudio.com/games/monopoly/

"Create a free, private account, add your friends, start a game from your group chats and move automatically to video chat when it begins."

Uses account system called bubble.

Account creation:

- Log in with Google or Facebook
- Or create an account using email

Friends:

- Friend code: Unique account ID
- Invite friends link

Customization:

- Avatar: Select a premade icon

- Name: Choose your own name. Can be duplicated since there is a unique account ID called a friend code
- Notifications: Switch on or off to be alerted when you receive new messages, friend requests, or game invitations from friends.

https://www.marmaladegamestudio.com/best-monopoly-strategy/
^ These below are words from this link ^

Strategies can tell a lot about gameplay mechanics. What they are, how they work, and how to take advantage of them. Here "are some simple strategies that can help tip the odds in your favour":

1. WHAT TO BUY
   a. Buy the orange set
      i. "Statistically, the most landed-on square is Jail because there are so many ways to get sent there (2 "Go to Jail" cards; roll doubles 3 times in a row; the Go to Jail square), and the orange set has a high likelihood of being landed on from that position."
      ii. "The "Advance to Pall Mall (or St Charles Place)" card puts you 7 spaces from Marlborough Street, and 7 is statistically the most common roll in the game."
      iii. "The "Go back 3 spaces" card puts you on Vine Street 1 in 3 times."
      iv. "The "Advance to the nearest utility" card puts you on the Electric Company 2 out of 3 times, which is just 1 roll away from the Oranges."
   b. Blue set controversy
      i. "The dark blue set raises controversy. Yes, you can end the game with a hotel on Mayfair for M2000 rent, if some poor unfortunate is unlucky enough to land on it. But those properties are on the "bad" side of the board. Anyone who lands on the "Go to Jail" square will automatically skip that entire stretch. The dice rolling odds are just not in favour of landing on those two properties."
      ii. "On the flip-side there's the dreaded "Advance to Mayfair" Chance card."
      iii. "It's up to you. If you trade them away, other players are likely to overpay for them, so you can make some easy money early in the game by selling them on."
   c. Railroads
      i. "The Railways are another dividing point. Ken Koury and 2015 MONOPOLY World Champion, Nicolò Falcone, think they're a waste of space. But recognised MONOPOLY expert, Craig Way, thinks you can win with the railways alone!"
      ii. "There's no doubt they can be a lucrative asset. If you own 3-4 they can bring in a lot of money even early in the game. If you have all 4, you're looking at potential rent of M800 in a single round, and that's with only 1 opponent. Now, to be fair, luck would have to be on your side. But even half of that isn't bad! Add a couple more players to the game and the railways can be a source of steady income."
2. MANAGING CASH FLOW
   a. Buy every property you land on to deprive other players of opportunity and to make good trades later. (Paraphrased)
      i. Take advantage of mortgages if you need to raise funds (Paraphrased)
3. BUYING HOUSES

a. Statistically it is best to buy 3 houses per set. (Paraphrased)
b. "3 houses is when rents start to become painful. If you're choosing between adding a 4th house or starting to build on another set, start buying houses for the other set."
c. "On the Orange set, you can buy 3 houses for M1,500 and get rent of M1000. In comparison, for the Green set you'll need to spend M3000 for M1,200 rent."

4. JAIL CAN BE THE SAFEST PLACE
a. Pay to get out jail early in the game. Later in the game it can be a safe place to stay.
b. "However, once people start owning sets it can be the safest place to be. In the official rules, you can still collect rent while in jail, so for your 3 turns you can be raking in the cash with no risk to your bank balance!"
c. "On the flip side, if the game is young and you need the oranges, you're 25% more likely to land on those squares by rolling doubles to get out of jail. So the choice is yours! Pay the M50 and get back in the game, or risk watching other players snap up the prize properties while you wait for a 25% higher chance of landing on the right square."

5. KEEP AN EYE ON THE CARDS
a. The Community Chest and Chance cards remain in the same order throughout the game, with used cards going to the bottom of the pile. There are only 16 in each deck, so it is possible to keep track of what's coming up.
b. Knowing that the "Advance to Pall Mall" card could be just around the corner, might mean you buy a few houses there at just the right time. The same can be said for the "Property Maintenance" card, which might stop you from upgrading to hotels until it's safely out of the way!

Game Mechanics

1. Players
2. Money
   a. The Bank
   b. Bankruptcy
3. Properties
   a. Buying
   b. Sets
   c. Rent
   d. Houses and Hotels
      i. Selling
   e. Mortgages
   f. Trading
4. Movement
   a. Dice roll RNG
5. Cards
   a. Community Chest
   b. Chance
   c. Get out of jail free
6. Jail
7. Trading

Shop

- Offers & Bundles
- Complete collection
    - Buy everything at once
- Explorer Pack (different property names based on different countries)
    - $4.99
    - Ability to buy it as Vintage Adventurer Edition
- Themes (Boards and Tokens of the same theme sold as a bundle)
    - $6.99/theme)
- Boards (Different types of cities, environments and board colors)
    - $4.99/board
- Tokens (Character pieces)
    - Single tokens for $1.99
    - Bundles of four tokens for $4.99
    - Bundles of six tokens for $6.99 or $7.99, depending on the collection

Network Topologies
https://www.marmaladegamestudio.com/games/monopoly/

Single Player

Pass & play

- Local or Couch multiplayer

Open or private online multiplayer

Building the Perfect baldorf Multiplayer

For those that don't know, baldorf's multiplayer is asynchronous meaning that players do not have to be online at the same time to play a game. This comes with its pros and cons. One such pro is that you can play your turn whenever you want. And one con is that games can last an eternity.

But what would baldorf multiplayer look like if it were synchronous? That is what I hope to achieve in this document. I will share examples of synchronous multiplayers that I got inspiration from, and which features I selected to use in my so-called perfect version of baldorf multiplayer.

Second Edition

Instead of marketing it as a perfect version why not keep the old and just add this version as a new game mode? Gamers can either play Competitive or Casual.

- Casual is the current asynchronous version
- Competitive is my new synchronous version

Features

The games we will be looking at are Marvel Snap, Clash of Clans, and Clash Royale. Notable features include

- Playing turns at the same time to speed up matches. (Marvel Snap, Clash of Clans Versus)
- Turns have a time limit to speed up matches. (Marvel Snap, Clash of Clans Versus, Clash Royale)
  - When there is 15 seconds left, make the edges of the screen red. (Clash Royale)
- Live spectate feature to watch your opponent complete their turn, after you've completed yours. (Clash of Clans Versus)
  - Emote to throw off you player's groove (Clash Royale)
- Turns auto start after 15 seconds to speed up matches. (Clash of Clans)
  - Timer starts once the last player finishes their turn.
- Replay system to watch you or your opponent's turns at the end of the match. (Clash of Clans Versus)
  - View a single turn at a time
    - Turn 1
    - Turn 2
    - Turn 3
  - Ability to change the speed of replays
    - 0.5x
    - 1x
    - 2x
    - 4x
- 1v1 matches. This could result in competitive leagues making the game more sustainable long term. (Clash Royale, Clash of Clans Versus Battles, Marvel Snap)
  - Dorf score to keep track of how good you are (Clash trophies, Marvel Snap competitive cubes)
- Profiles. Players have a character they can choose. (Clash Royale, Marvel Snap)
  - This will be displayed on the match found screen.
  - Show character and name.
  - You are on the top left, opponent is on the bottom right with a VS in the middle.
- Scoreboard at the end of each turn
- Forfeit. Players have the opportunity to forfeit at the end of each turn if they don't think they will be able to win. (Marvel Snap's retreat feature)
  - Forfeiting cuts the dorf score lost in half for each turn
  - Losing a match: 32 score
  - Forfeiting before start of turn three: 16 score
  - ** ** ** ** ** two: 8 score
- Leaderboard to view top dorf scores.
- Edges of the screen turns red when there is 15 or less seconds left in the match. (Clash Royale)

Inspiration for this idea

Jeff mentioned in our 6th thesis meeting that I could write about how I would implement the features from the games I've been researching into baldorf. This sparked the idea: What if I pick elements of multiplayers from different mobile games and build the perfect multiplayer with them in the context of baldorf.

Defense of this idea

This wouldn't be a report on my team's current senior design work because we are currently making an asynchronous multiplayer. This new multiplayer would be synchronous and more of a hypothetical notion. I likely won't be able to implement everything in this idea, but it will be interesting to explore and write about. I would also like to make mockups of what it would look like. Who knows, maybe future baldorf teams could read the paper and find inspiration in my ideas to improve upon the systems we've built or implement new ones entirely.

Where to go from here

I already have quite a bit of research on the features because of my analysis of turn-based multiplayer games so I can use some of that to write this topic. So, now I will need to expand on the ideas I've stated above. I likely won't do any further research on game features since I need to have a rough draft by January 18th. But since the paper isn't actually due until May, I probably have some leeway. That being said, it would be best to get started while I have the inspiration. I can always research more along the way.

Mockups

Designed using Figma. View my work here:

https://www.figma.com/file/GxPZ85e5UooHmkF18FxGaS/honors-thesis-baldorf?node-id=0%3A1&t=XA7owpR8dCb3HzWc-1

Match Summary: Background should be a blurred stadium

- Winning a full match
- Losing a full match
- Forfeiting after turn 1
- Forfeiting after turn 2
- Opponent forfeiting after turn 1
- Opponent forfeiting after turn 2

Matchmaking

- ~~Select multiplayer mode~~
- ~~Home screen~~
- ~~Searching for a match~~
- ~~Match found~~

Match Log

- Minimized
- One expanded

Gameplay

- ~~Playing a turn~~
- ~~Playing a turn with 15 seconds left~~
- ~~Playing a turn with opponent emotes~~

- Pause menu during a turn
- Forfeit during a turn

Turn Summary

- Win
- Loss
- Turn in progress
- Forfeit menu

Live Spectating

- Watching a turn
- Emotes menu

Replay

- Watching a turn with emotes

Leaderboard

- Dorf Score
- High Score

Profile

- Profile
- Character selection
- Dorf selection
- Stadium Selection
- Edit name