# Depicting the Process of Modern Data Streaming

UTILISING COMPUTER GRAPHICS TO INFORM

Joel Foster | COSC3000 | 8/06/2021

# Contents

# Introduction

Due to the highly technological nature of our society, understanding the mechanisms of the internet is of interest to many people. In particular, due to the evergrowing reliance on online streaming services as our main forms of entertainment, understanding the processes and vast resources required to facilitate such streaming services is imperative. Whilst this information may be freely available online, an effective graphical representation is non-existent. Also, since tech space is constantly evolving, any previously constructed graphical representations become quickly outdated and convey only partial information or, in the worst case, misinformation. Computer graphics can be a useful tool when trying to convey and explain intricate processes and concepts. Additionally, interactive components can help to engage the user to learn more efficiently. As such, it seems pertinent to construct new graphics to ensure the correct information is conveyed clear and concisely, in addition to clarifying any current misinformation out there.

## Aims

The primary aim of this report is to educate the general population on the resources and processes involved when streaming from a service such as Netflix. In pursuit of this goal, an appropriate graphical representation will be constructed. This will be achieved by:

- Pre-rendered 3d animations
- Realtime 3d interactive space

Through these graphical representations, this project will show the key important steps as well as highlighting the vast distance data travels in order to be streamed. Additionally, the project will highlight key resources which are utilised during the streaming process.

# Methods

## Tools

The project consists of two key graphic types. Each type was generated using a different computer graphic generation software. These types and their respective software are (note: 3d in terms of world space):

- Pre-rendered 3d animations [1]
    - Constructed using Blender
- Realtime 3d interactive space [2]
    - Constructed using Unreal Engine

The two respective graphic software were used because of their relative ease of use, whilst also containing several ways to perform intricate graphic techniques.

# Steps of Graphic Representations

1. Server Interactive Space [2]
    a. Netflix/Amazon Server
2. Fibre Optic Cable Animation [1]
    a. Trans-Atlantic data travel
3. Server Interactive Space [2]
    a. ISP server
4. Copper Wire Cable Animation [1]
    a. Travelling to your home

# Results

## Fibre Optic Cable Animation [1]

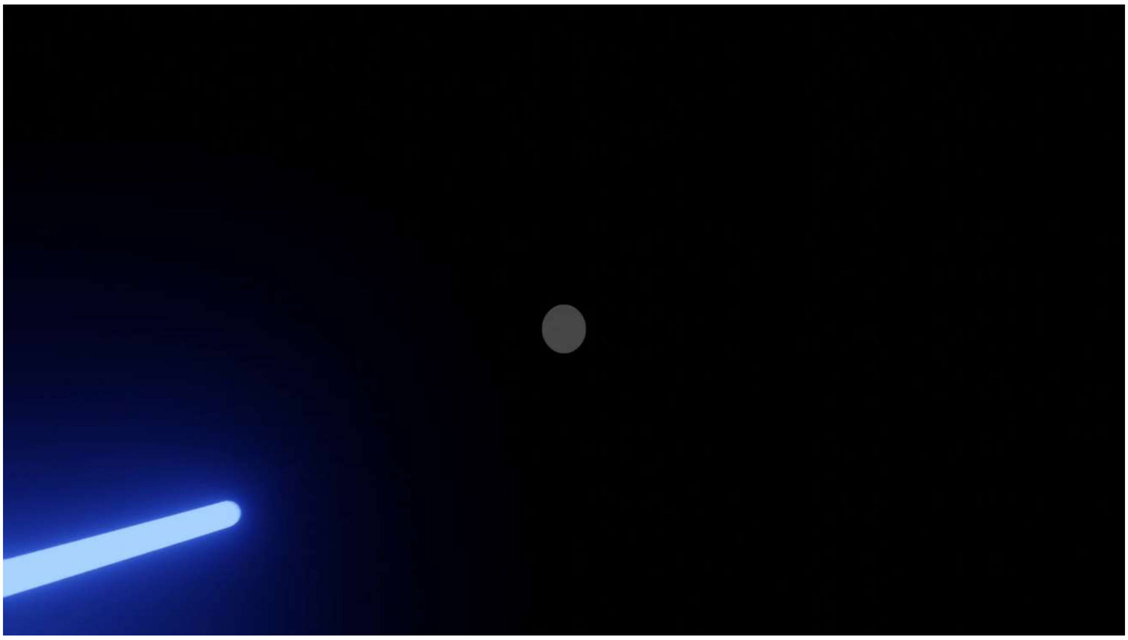

*Figure 1 - Fibre Optic Cable (travelling) Animation Start*

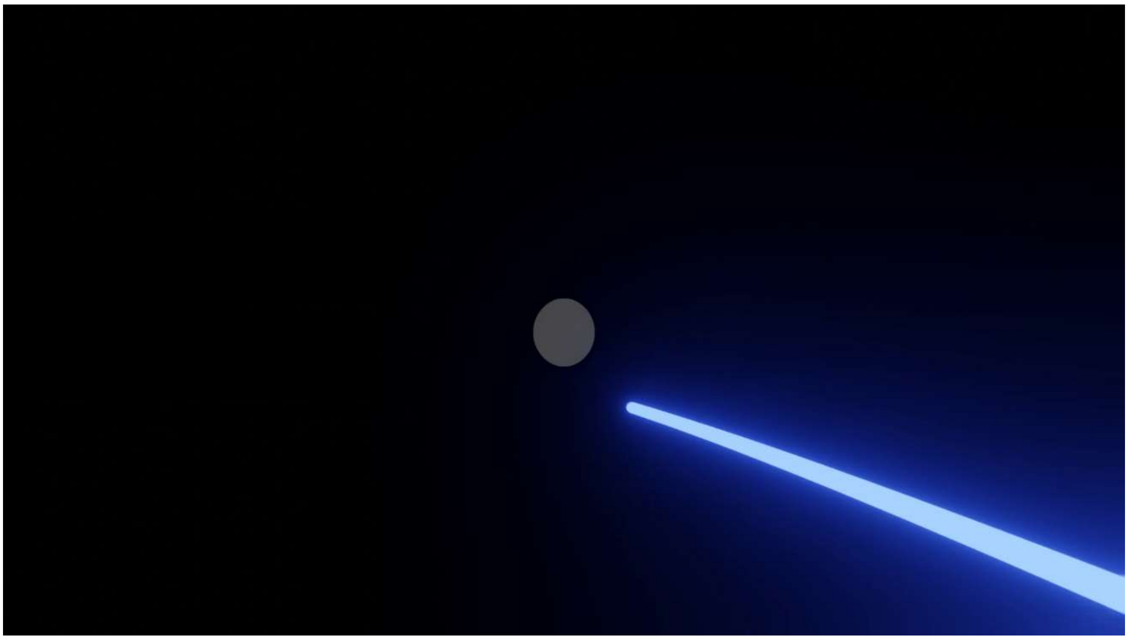

*Figure 2 - Fibre Optic Cable (travelling) Animation Near End*

Techniques:

- Models:

This animation made use of only simple surfaces. A cylinder was used to represent the cable while small spheres were used to represent a single point of the laser.

- Materials:

In Blender, materials define how objects interact with light (shader). Only the surfaces of the objects were rendered, as rendering the full object was unnecessary.

The Fibre Optic Cable animation utilised an emitter, which every frame would emit a glowing sphere. This process would artificially simulate a light beam travelling through a cable bouncing off each edge. The emitter was not rendered in the final render. The glowing sphere was made by applying a light blue tint with an emitter surface. A simple cylinder was used to represent the cable with a black material. It was decided that this material should not reflect light as the light beam should not be emitting light to be reflected. As such a black emission surface was utilised.

- Lighting:

The only light source within the scene is the laser passing through the wire. As such the light primarily emanates from the path of the laser and does not reflect off any surfaces. As shown in Figure 1 & 2, unrealistically light emits from the laser. This was decided to draw attention, to the laser and its path despite it not aligning with reality.

- Perspective:

The camera followed the laser down the cable. As such a perspective camera was used. Additionally, it was decided to have an image sensor width of 36 mm and a focal length of 14 mm. This further emphasised the feeling of fast accelerated motion from the camera's perspective. Key frames were used to control the positions of both the laser and the camera through the animation.

- Animation
    - The animation was rendered frame by frame using the cycles engine.
    - As such the lighting was generated by ray tracing.
        - This resulted in a much, cleaner image and reflections however took considerably longer to render than the eevee engine (rasterisation)
            - This was done, since the necessary hardware and time was available and the effect was extremely noticeable.
            - Additionally, the animation was relatively short at 240 frames.

Other Effects:

- Bloom
  - Shader Effect
  - Implemented to accentuate the laser.
- Motion Blur
  - Used to further emphasise the movement of the camera since there are only two distinct subjects in the shot (end of pipe and laser)
- Ray Tracing
  - Using the cycles engine
  - Increase in quality of lighting and texture effects

## Copper Wire Cable Animation [1]

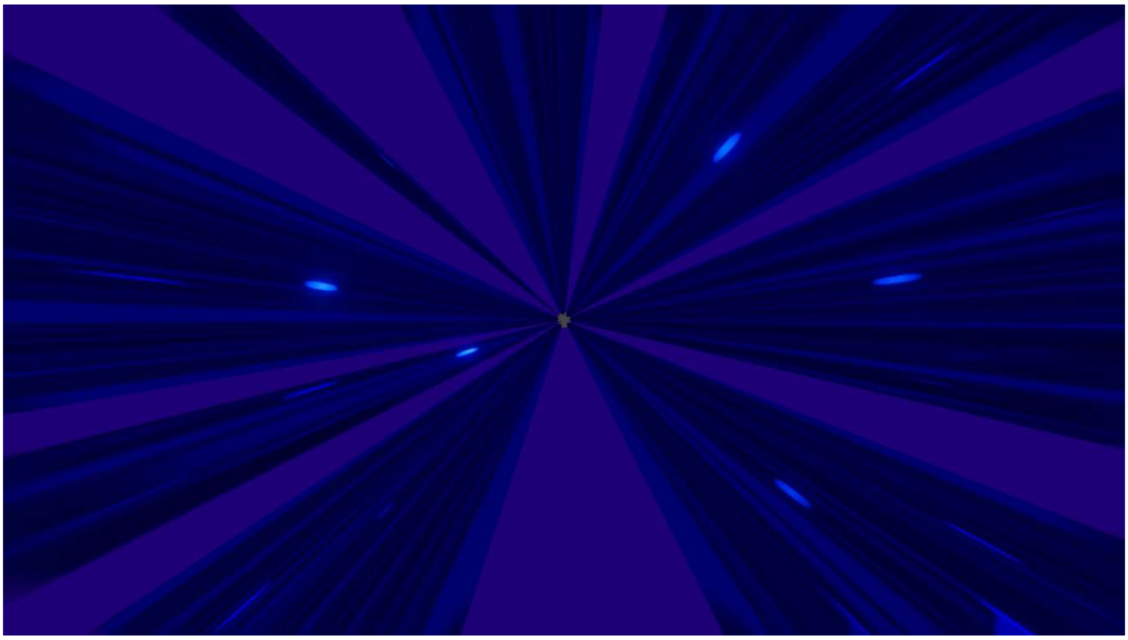

*Figure 3 - Copper Cable (data travelling) Still Frame from Animation*

Techniques:

- Models:

This animation made use of only simple surfaces. The light elements had no shape and thus were not rendered. A cylinder was used to represent the outer enclosing, while stretched/transformed spheres were used as the data cables.

- Materials:

Similar to the Fibre animation, only the surfaces of the objects were rendered, as rendering full objects was unnecessary.

As shown in Figure 3, the inner 'data' cables had a glossy material applied and were coloured dark blue. This distinguished the data cables from the outer casing. Finally, the small lights emitted a weak directional light towards the cables which was then reflected towards the camera. A simple cylinder was used to represent the cable with a dark purple material. It was decided that this material should not reflect in order to further distinguish the inner data cables against the outer casing.

The choice to use glossy cables, provided a much better and more realistic effect of data travelling, then using textures to achieve a similar effect.

- Lighting:

Several light sources are used to signify data passing through the metallic cables. These light sources reflect off the metallic material and combined with the accelerating camera, create this data flow effect. No external light source was used in order to better simulate the dark conditions of the data cable. To this end, the light sources had to be carefully controlled in order to not overflood the scene with diffused light.

- Perspective

See the perspective section of Fibre Optic Cable Animation. The same measures were taken.

- Animation

See the animation section of Fibre Optic Cable Animation. The same measures were taken.

Other Effects:

- Bloom:
    - Used to highlight the data points (as they appear in frame briefly)
- Screen Space Reflections
- Motion Blur
    - Used to simulate the user moving through the cable (distort lighting)
- Ray Tracing
    - Using the cycles engine
    - Increase in quality of lighting and texture effects
- Ambient Occlusion
    - Used to distinguishing the data lines from the similarly coloured outer casing when lit.
- Global Illumination
    - Allows the light to be reflected off the glossy data cables into the camera, simulating data bits flowing.

## 3d Interactive Environment [2]

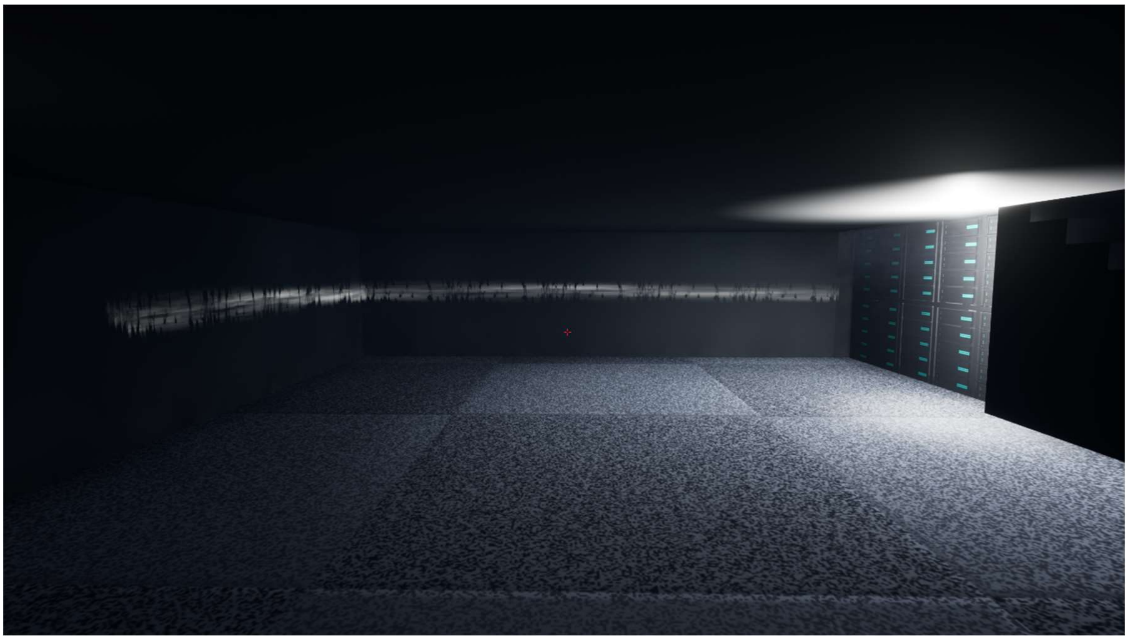

*Figure 4 - Interactive Environment (IE) Starting Area*

Techniques:

- Models:

Most objects were created using predefined ‘classes’ existent in Unreal Engine. Transformations were then applied using the inbuilt editor (rotation, resizing and moving). Each model consisted of a static mesh, material, lighting map and physics properties.

- Materials & Textures:

In Unreal Engine, materials define how objects interact with light (shader). Additionally, all models were rendered with volume since physical interactions would occur during the runtime of the environment. Additionally, imported textures used a sharpening filter ‘sharpen4’ when constructing their mipmaps.

Textures of note are:

1. Main floor
    a. Made of carpet
2. Walls & 2$^{nd}$ Floor
    a. Made of polished concrete
3. Animated Data Path
    a. Does not interact with light, but has a slight emission of white light

4. Server Stacks
    a. 2d texture tiled onto a 3d transformed cube (with a slight reflective material)

- Lighting:

There are 3 light sources located throughout the environment. Each light source serves to illuminate the environment so the player can traverse the area. Additionally, light sources highlight areas of key interest for the player. Light also interacts with various materials, such as transparent and highly reflective materials. Specular reflection can be observed on the 2nd floor ground and the server racks. Additionally, refraction of light can be observed within the glass in Figure 4.

Other Effects:

- Screen Space Reflections
    - Creating subtle reflections in the glass and on the polished rock floor
- Motion Blur
    - Slightly used to assist in providing the character the feeling that they are moving
        - However, since the space is relatively small and the player character (PC) moves slowly throughout the space, the effect is negligible.
- Rasterisation
    - Used over ray tracing as it is much faster and since Unreal Engine is a real time 3D engine.
- Anti-aliasing
    - To smooth object edges
    - FXAA was applied due to its efficiency compared with other anti-aliasing techniques as well as its increase in visual quality.
- Global Illumination
    - Enables the main room to be indirect lit by a single light source.
    - Pre-computed and stored within textures (baking directional light maps)
        - Since lighting does not change within the environment
- Anisotropic Filtering
    - Enabled by default
    - Extremely important as in the 3d environment, textures can become increasingly stretched as the player views them at several different angles.
- Cursor Overlay
    - Allow user to interact with objects in the environment and to help with trigger events.

Attempted Effects:

- Ray Tracing Light/Ray Traced Global Illumination + Path Tracing
    - The environment was still sustainable, however there was a significant performance deficit with no comparable quality gain.
- Ray Traced Translucency
    - The effect improved the interaction between light and glass (shown in Figure 8) however also had a noticeable performance deficit.

*Figure 5 - 2nd Floor of IE*

*Figure 6 – Side View of 2$^{nd}$ Floor Server Stack*

The figures above, demonstrate how light interacts with the surrounding environment. In Figure 5, the primary light source is surrounded by two server stacks, this leads to light being reflected between the server stacks as well as escaping light taking a cone shape. This is much clearer in the side view presented in Figure 6. Figure 5 also demonstrates the effects of Global Illumination and Anisotropic Filtering.

*Figure 7 - Example of Decal*

*Figure 8 - Example of Light Interacting with Transparent Objects*

The figures above demonstrate the texturing method used for the server stack. An image was tiled across a rectangular prism. Figure 7 also demonstrates the use of an applied decal to the server stack. Figure 8 also shows the effect of light traveling through a transparent material. It can be seen that the glass slightly distorts the textured server rack behind as light bounces through it.

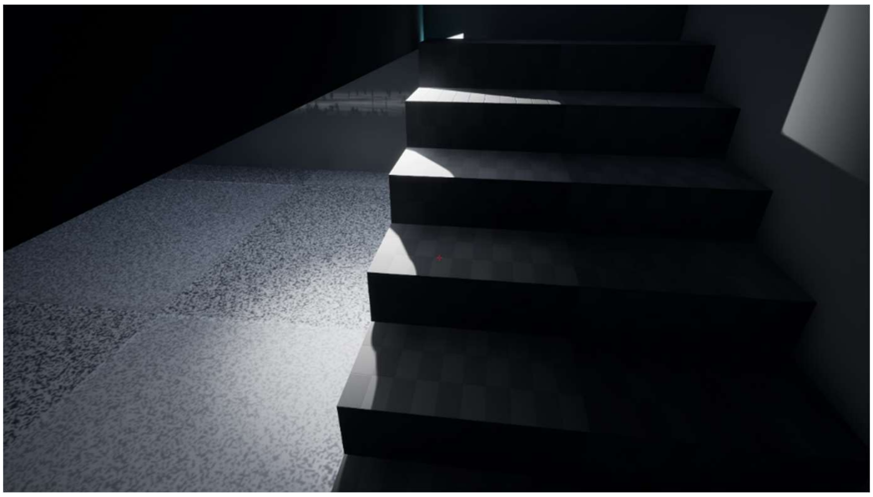

*Figure 9 - Stairs Between Levels*

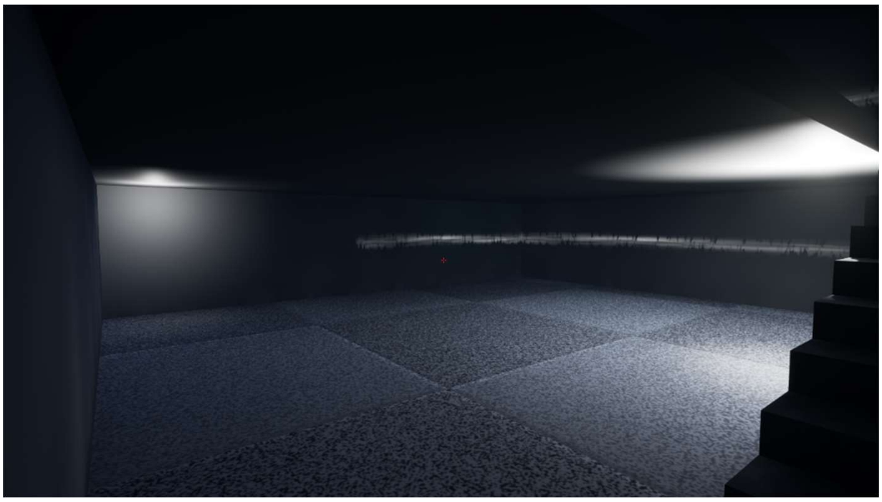

*Figure 10 - Corner View of First Floor*

Figure 9 demonstrates the behaviour of light when interacting with an uneven surface. Additionally, a clear shadow of the stair case can be seen on the right, demonstrating how shadows are constructed. Figure 10, on the other hand, shows the interaction of two different strength light sources. This highlights how both contribute to global illumination of the room, whilst having strong direct light on their surrounding areas.

# Discussion

## Successes

The project has achieved its aim of producing an educational, interactive animation of the process of entertainment streaming. The content has a natural flow, with each animation/graphic representing a step in the process of supplying data. Finally, the transition animations are of appropriate length and keep the user's attention, with appealing visuals. The 3d interactive environment allows users to explore a server space (one of several) which are involved in data travel, whilst also providing a semi-realistic depiction of an actual server space.

## Limitations/Areas for Improvement

Due to time constraints, the 3d interactive environment was both significantly smaller than hoped for as well as containing few educational elements. As such, if this project was revisited, these would need addressing. Due to both time and resource costs, the sampling rate on both transition animations was not the highest it could have been, however they maintained most visual fidelity. In general, the level of detail was quite lacking given the realistic context of the topic. To address this, use of more complex textures and refining pre-existing materials/effects should be done.

Despite the natural flow of the graphics, I believe a secondary model (such as an outer space 3d earth model) could help to connect each graphic significantly better whilst also providing much needed context for the end user. This was attempted during the project process, however, was ultimately scrapped due to time restrictions and the need to focus on the other graphics of the project. This severely affected the end user's experience and interactivity of the project as a whole.

Additionally, to increase realism of the 3d environment, a player character model should be constructed which generates shadows and can help connect the player to their model (see Appendix [d]). A smoke effect was attempted to simulate the vapor which might be in the atmosphere (due to the cold conditions), however the effect was barely visible so it was removed.

An interesting possible modification of the 3d space, could be the use of real time ray tracing (given the necessary hardware). However, this would limit the possible audience of the graphics as not many would have the necessary hardware. Another possible addition would be the addition of smoke/mist effects to indicate the cold environments these server rooms are usually contained in.

In general, the project could be significantly improved with the construction of appropriate high res textures and fine tuning of the lighting.

## Personal Reflection

Despite these areas for improvement, I am proud of the graphics I have produced. In particular, I am proud of my ability to learn and use a range of computer graphic software to generate two appropriate graphical representations which complement each other well. Additionally, I have learned techniques both from the course work and external research, which have been demonstrated clearly within this report. As such, the graphics produced are clear and have some educating features.

# Appendix

List of attachments:

- FibreOpticCable.mkv (3d Animation) [a]
- StrdCable.mkv (3d Animation) [b]
- Packaged.zip (Zip file containing exe and all source files for 3d interactive environment) [c]
- Figure 11 (Image demonstrating shadowless PC) [d]

*Figure 11 - Shadowless Player Character*